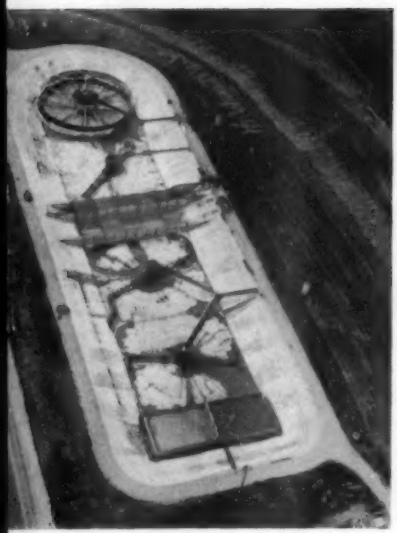
JULY 1958

Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 50 • NO. 7



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TREATMENT PLANT INNOVATIONS Hartung

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Journal

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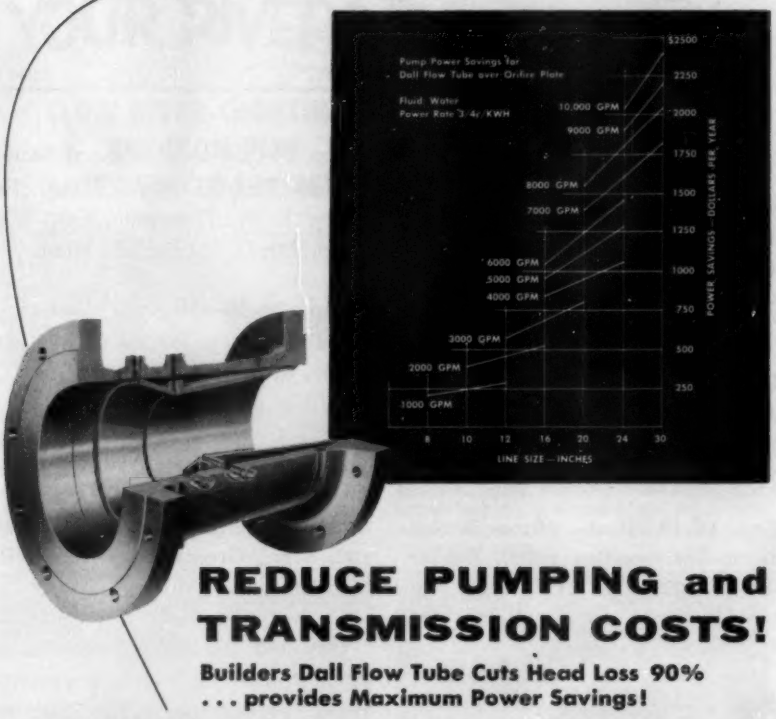

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AWWA SECTIONS

Sep. 8–10—Michigan Section, at Pantlind Hotel, Grand Rapids. Secretary, T. L. Vander Velde, Chief, Section of Water Supply, State Dept. of Health, DeWitt Rd., Lansing 4.

Sep. 10–12—New York Section, at Lake Placid Club, Lake Placid. Secretary, Kimball Blanchard, Rm. 1525, 19 W. 50th St., New York 20, N.Y.

Sep. 15–17—Rocky Mountain Section, at Cosmopolitan Hotel, Denver, Colo. Secretary, V. A. Vaseen, Ripple & Howe, 426 Cooper Bldg., Denver, Colo.

Sep. 17–19—Ohio Section, at Statler Hotel, Cleveland. Secretary, J. H. Bass, Robert F. McGivern & Assocs., 1771—5th Ave., Columbus.

Sep. 17–19—Wisconsin Section, at Hotel Wausau, Wausau. Secretary, Harry Breimeister, Chief Utilities Engr., City Engineer's Office, City Hall, Milwaukee 2.

Sep. 22–24—Kentucky-Tennessee Section, at Peabody Hotel, Memphis, Tenn. Secretary, J. Wiley Finney Jr., Howard K. Bell, Cons. Engrs., 553 S. Limestone St., Lexington, Ky.

Sep. 24–26—North Central Section, at Hotel Duluth, Duluth, Minn. Secretary, L. N. Thompson, Gen. Mgr., Water Dept., St. Paul 2, Minn.

Sep. 28–30—Missouri Section, at Hotel Governor, Jefferson City. Secretary, Warren A. Kramer, State Office Bldg., Jefferson City.

Sep. 28–Oct. 1—Alabama-Mississippi Section, at Buena Vista Hotel, Biloxi, Miss. Secretary, C. M. Mathews, Mgr., Greenwood Utilities, Box 866, Greenwood, Miss.

Oct. 1–3—Canadian Section, Maritime Branch, at Lord Beaverbrook Hotel, Fredericton, N.B. Secretary, J. D. Kline, Asst. Mgr. & Chief Engr., 162 Lady Hammond Rd., Halifax, N.S.

Oct. 15–17—Iowa Section, at Fort Des Moines Hotel, Des Moines. Secretary, J. J. Hail, Supt., Water Dept., City Hall, Dubuque.

Oct. 19–22—Florida Section, at Golden Gate Hotel, North Miami Beach. Secretary, John G. Simmons, Plant Supt., West Palm Beach Water Co., Box 1311, West Palm Beach.

(Continued on page 10)

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Coming Meetings

(Continued from page 6)

Oct. 23–24—West Virginia Section, at Daniel Boone Hotel, Charleston. Secretary, Hugh W. Hetzer, Engr., Design & Construction Dept., Union Carbide Chemicals Co., Box 8361, South Charleston 3.

Oct. 23–25—New Jersey Section, at Hotel Madison, Atlantic City. Secretary, A. F. Pleibel, Dist. Sales Mgr., R. D. Wood Co., 683 Prospect St., Maplewood.

Oct. 28–31—California Section, at Ambassador Hotel, Los Angeles. Secretary, Roy E. Dodson Jr., Supt. of Production, Water Dept., Balboa Park, San Diego.

Oct. 29–31—Chesapeake Section, at Hotel Dupont, Wilmington, Del. Secretary, Carl J. Lauter, 6955—33rd St., N.W., Washington 15, D.C.

Nov. 5–7—Virginia Section, at Jefferson Hotel, Richmond. Secretary, J. P. Kavanagh, Dist. Mgr., Wallace & Tiernan Inc., 213 Carlton Terrace Bldg., Roanoke.

Nov. 10–12—North Carolina Section, at O. Henry Hotel, Greensboro. Secretary, D. Y. Brannock, Supt., Water & Sewage Plants, Burlington.

OTHER ORGANIZATIONS

Aug. 27—Water Pollution Abatement Conference, sponsored by Illinois Chamber of Commerce, Sherman Hotel, Chicago, Ill.

Sep. 1–13—2nd International Conference on Peaceful Uses of Atomic Energy, Geneva, Switzerland.

Sep. 7–11—World Power Conference, Canadian Sectional Meeting, Queen Elizabeth Hotel, Montreal, Que. Write: Canadian National Committee of the World Power Conference, Rm. 500, 150 Wellington St., Ottawa 4, Ont.

Sep. 15–20—International Congress on Large Dams, Statler Hotel, New York, N.Y. For information, write: US Committee on Large Dams, c/o Engineers Joint Council, 29 W. 39th St., New York 18, N.Y.

Oct. 5–8—Annual Conference & Products Exhibit, National Institute of Governmental Purchasing, Hotel Statler-Hilton, Boston, Mass. For information, write: Albert H. Hall, Exec. Vice-Pres., NIGP, 1001 Connecticut Ave., N.W., Washington 6, D.C.

Oct. 5–9—Federation of Sewage & Industrial Wastes Assns., Sheraton-Cadillac Hotel, Detroit, Mich.

Oct. 13–17—American Society of Civil Engineers, New York, N.Y.

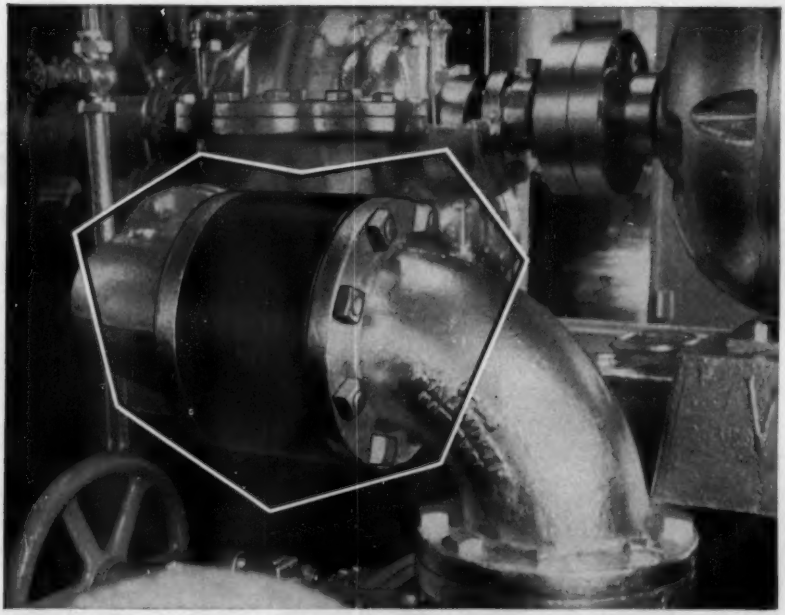
Oct. 20–24—National Safety Congress & Exposition, National Safety Council, Chicago, Ill.

Oct. 27–31—National Metal Exposition & Congress, Public Auditorium, Cleveland, Ohio.

Nov. 17–19—National Fire Protection Assn., Pittsburgh, Pa.

Nov. 18–20—National Conference on Standards, American Standards Assn., Hotel Roosevelt, New York, N.Y.

Nov. 30–Dec. 5—American Society of Mechanical Engineers, New York, N.Y.



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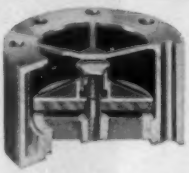
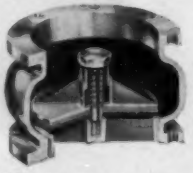


STYLE "G"—2 to 10"



STYLE "GB"—6" and up

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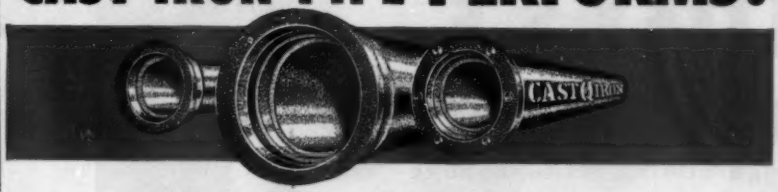
ANY PIPE CAN PROMISE...

50 YEARS YOUNG! This 36" Cast Iron Pipe feeder main was installed in 1907. Taken up in 1954 because of relocation project, it was relaid in 1956 for a bypass line around new highway interchange.

Close-up of section of above pipe 1,958 feet of which was cleaned and reused.

MODERNIZED **cast iron**

CAST IRON PIPE PERFORMS!



What other pipe offers you LONG LIFE + STRENGTH + HIGH FLOW CAPACITY?

Don't doubt when you buy pipe—specify cast iron and be sure of...

1. **LONG LIFE...** 42 North American cities are still using cast iron water mains laid 100 years and more ago. Hundreds more have passed the 50 year mark.
2. **BEAM STRENGTH...** Cast Iron Pipe is inherently tough... stands up under heavy traffic load, soil displacement and disturbance.
3. **HIGH FLOW CAPACITY...** Cement lined cast iron pipe and fittings will not tuberculate... delivers a full flow for the life of the pipe.
4. **EXTERNAL LOAD RESISTANCE...** 6" Class 150 Pipe withstands a crushing load of 17,900 pounds per foot... nearly 9 tons.
5. **CORROSION RESISTANCE...** Cast Iron Pipe effectively resists corrosion... vital factor in its long life and dependability.
6. **TIGHT JOINTS...** A full range of leak-proof, low cost, easy-to-assemble joints for pipe and fittings are available for all conditions.

You've read and heard thousands of words—all selling pipe.

But make no final choice before you ask this simple question: What pipe offers you not one, not two but *all* the factors that spell long, trouble-free life and dependability.

The answer is... cast iron pipe. Performance made it... and performance keeps it... America's No. 1 Water Carrier.

Its service record *proves* it!

THE MAN WHO CHOOSES CAST IRON PIPE TODAY WON'T PAY FOR IT AGAIN TOMORROW!

CAST IRON

Cast Iron Pipe Research Association
Thos. F. Wolfe, Managing Director
Suite 3440, Prudential Plaza, Chicago 1, Ill.

pipe FOR MODERN WATER WORKS

BEATS ANYTHING YOU'VE EVER USED FOR WATERPROOFING POROUS MASONRY

PATENTED

SILITEX S.F. with SILICONES

ADDED DURING MANUFACTURE

Silitex S.F. is an amazingly effective decorative waterproofing product containing SILICONES, activated metallic compounds and finely ground ingredients formulated with cement powder as a base.

It comes to you *ready for use* with all ingredients scientifically pre-mixed. No additives, no measuring, no mixing is necessary. You simply add water and use.

Contrary to the shrinkage phenomena of most paints, Silitex S.F., when applied, *expands into an insoluble non-reversible compound that penetrates and quantitatively fills even microscopic pores in masonry.*

After application, the action of Silitex S.F. causes the Silicones to *migrate to the surface of the compound in either direction.* On the masonry side, Silicones actually *pass into the masonry,* thus creating a chemical as well as a mechanical bond, and at the same time, *lining the pores with Silicones.*

The action of Silicones produces a remarkably hard surface. Water coming into contact with a silicones-embedded surface, is *repelled so violently that it actually globules up and rolls away.*

When you apply Silitex S.F. to porous masonry, you are applying material to a like material with the same coefficients of expansion. This means adhesion so great that the possibility of *checking and peeling is practically eliminated.*

When applied either above or below grade, Silitex S.F. can be expected to *waterproof structurally sound masonry for a period of five years and more.* Available in five pastel colors.

BELOW GRADE

Silitex S.F. definitely stops water seepage. While it forms an unusually hard surface, water vapor still passes through the compound and the wall breathes. Unlike other coatings, Silitex S.F. *will not blister or peel* from water accumulation in the wall.

ABOVE GRADE

On outside porous masonry surfaces, Silitex S.F. effectively repels water—even wind-driven rain. Should water get into the walls through faulty flashing on parapet or windows, Silitex *will not peel.*

Silitex S.F. is applied to new grain elevator at Hudson, Kansas.

Most waterproofing compounds absorb water. Continual wetting and drying, freezing and thawing, breaks down the material. But due to the chemical nature and physical characteristics of the Silicones used in Silitex S.F., they are unaffected by oxidation and atmospheric conditions. Silitex remains highly resistant to weathering under the most severe conditions. And because of these same characteristics, rain-carried dirt cannot penetrate a Silitex surface, so is washed away in a self-cleaning action.

After Silitex has cured, you can paint over it with oil, vinyl, latex or acrylic base paints with every assurance that it will not peel or crack.

UPSON

Serving the Building Industry for 45 years

WRITE FOR DELIVERY INFORMATION

THE UPSON COMPANY
900 Silitex Division
Lockport, N. Y.

Please send complete technical information about Silitex S. F. ☐ Siliphane ☐

Name_____
Type of Business_____
Address_____
City_____ State_____

Housing Project Long Island, N.Y., protected against wind-driven rain with Siliphane

SILIPHANE

WORLD'S NO. 1
CLEAR WATER REPELLENT

Where clear Silicone waterproofing is needed, you can use Siliphane, knowing it is the best. Siliphane is guaranteed to contain 5 to 5½% Silicone solids.

Guthrie Water Works Operators . . .

Control panel for one of Guthrie, Oklahoma's 4 Rapid Sand Filters. Instrument dials (L to R) show loss of head, effluent flow, and rate of backwash. Air switches at bottom are used to shift control functions.

DIAL the FLOW RATE... then forget it!

thanks to FOXBORO PNEUMATIC CONTROL

"Dial the set point and flip a pneumatic switch". That's how they control effluent and backwash on rapid sand filters at the new Guthrie, Oklahoma, Water Treatment Plant. No valves to crank — no need to check the filters visually! Foxboro does it all quickly, dependably — automatically.

With Foxboro centralized Rapid Sand Filter Control, filtration rates can be set: remotely, from a panel in the operating gallery (as at Guthrie); or, automatically, from a sedimentation basin or clear well.

Find out how Foxboro Pneumatic Control can save you time and money. For full details, write for illustrated Bulletin 1-15A. **The Foxboro Company, 167 Norfolk St., Foxboro, Massachusetts.**

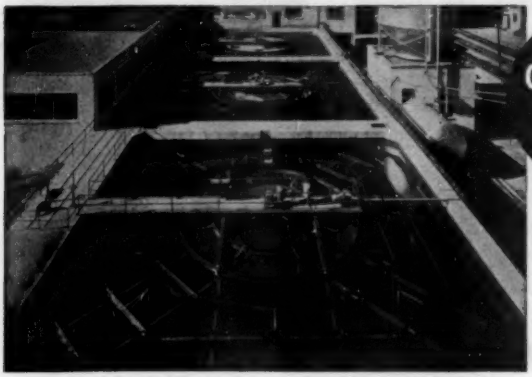
FOXBORO
REG. U.S. PAT. OFF.

AUTOMATIC CONTROL for RAPID SAND FILTERS

WALKER PROCESS

Clariflow

Orlando, Florida Water Treatment Plant includes three Walker Process Clariflows for lime softening as well as algae and color removal. The unit in the foreground, completed in 1954, increases the plant capacity to 24 MGD. The two original Clariflows were installed in 1949. Each unit is 56' square x 17' deep.



ORLANDO, FLORIDA

Consulting Chemists & Engineers — Black & Assoc. Gainesville, Fla.
Gen'l. Mgr. — Orlando Utilities Commission — Mr. C. H. Stanton, Mgr.
Orlando Water Dept.— Mr. L. L. Garrett

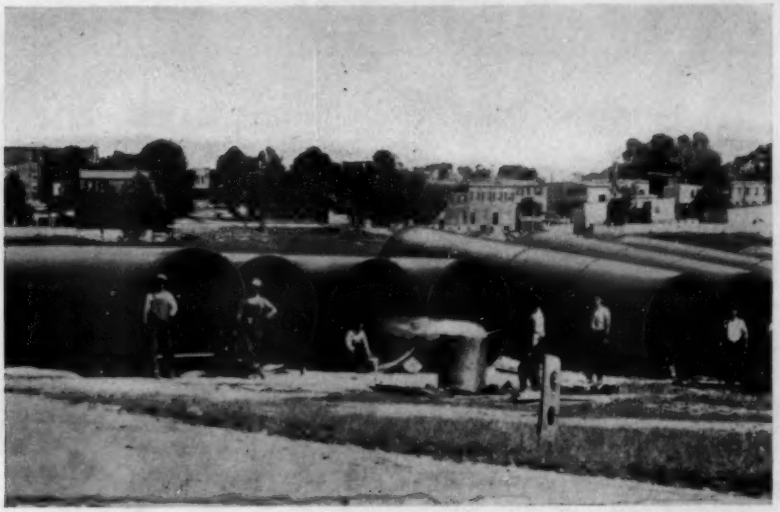
The Clariflow combines flocculation, good fluid mechanics and clarification in a relatively small tank. Mixing, flocculation, stilling and sedimentation are independently operated and controlled. The positive control of flocculation and clarification enables the operator to readily select the most economical method of operation when handling changeable water conditions.

Short circuiting tendencies are eliminated by means of exclusive multiple, tangential diffusers which simultaneously and equally distribute the flow. Balanced multiple surface weir troughs make efficient use of short detention periods and insure clarified overflows.

The Clariflow is applicable wherever there is a municipal or industrial need for water or waste treatment. It can be used in all operations including combined intimate chemical homogenizing, flocculation and clarification in rectangular, square or circular basins. The Clariflow gives excellent results in the treatment of municipal and industrial water for—softening—turbidity removal—color removal—algae removal. Industrially it is universally used in—oil separation and emulsion breaking plants—blast furnace flue dust thickening—paper stock reclamation.

Write for bulletin 6W46.

WALKER PROCESS EQUIPMENT INC.
FACTORY—ENGINEERING OFFICES—LABORATORY
AURORA, ILLINOIS



Applying coal-tar enamel in 1915.

Steel Pipe in good shape after 42 years

Way back in 1915, Baltimore's Board of Water Supply installed an 84-in. steel main to distribute water from the Montebello Filtration Plant. The 4057-ft-long line is made up of riveted ½-in.-thick plates, and was hand-daubed with old style Bitumastic coal-tar enamel.

Today, after 42 years of almost constant use, this line is still giving fine service, with no apparent loss of flow capacity. The last internal inspection of the line, in 1939, indicated the pipe and its coating to be in excellent condition.

Baltimore is but one of many cities that has had long and successful experience with steel pipe. And, since today's steel pipe is vastly improved—better fabricating methods, better joints, better protective materials—we can safely conclude that *there is no known limit to the service life of coal-tar enameled steel water pipe.*

COMPARE THE COSTS—This drawing compares a single 40-ft length of steel pipe with 16-ft lengths of rigid-walled pipe of the same inside diameter. The steel pipe has thinner walls and a smaller outside diameter; weighs only about one-fifth as much per ft of length. Results: the steel pipe costs less to ship, to handle, and to lay. It requires a smaller ditch, fewer bell holes, fewer joints—only 132 per mile.

TESTED FOR STRENGTH—Every length of steel pipe is hydrostatically tested at the shop in accordance with AWWA specifications—usually to double the working pressure. What's more, steel pipe can withstand from 3 to 4 times the working pressure before bursting. And steel pipe safely resists water-hammer, shock loadings, and surge.

LEAKPROOF JOINTS—100 pct bottle-tight joints are a practical reality with steel pipe, whether Dresser couplings or welds are used. That means no water wastage, no costly washouts. And you needn't fear contamination of the contents due to infiltration from without. These joints are quickly made, they're permanent, and they're strong.

CORROSION-RESISTANCE—Modern methods of lining steel pipe with hot-spun coal-tar enamel make it immune to corrosion and incrustation. There is no known time limit to this protection. Many tar-enameled lines have been in service for upwards of fifty years. Coal-tar enamel provides the smoothest surface obtainable, assuring high flow coefficients year after year. Coatings and wrappings protect the pipe from moisture, acids, and alkalis.

BEAM STRENGTH—Steel pipe has the structural strength that is characteristic of tubular steel. It can span long washouts; is often handled in multiple lengths during installation. And steel pipe can stand up under the weight of heavy cover.

WIDELY USED—Some recent users of Bethlehem Steel Pipe are New York City, New Orleans, Philadelphia, Savannah, Reading, Cincinnati, Atlanta, Omaha, Worcester, Colorado Springs, and Boston. Further proof of the superior qualities of steel pipe is its use in thousands of miles of large-diameter gas and oil lines, as well as in high-pressure penstocks throughout the world.

For further information about steel water pipe, kindly contact the nearest Bethlehem sales office.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

what price water?

WHAT PRICE WATER? is a 12-page, 4x9-in. booklet that calls to the attention of the reader the real value of public water supply. Comparing 1940 prices of a number of other common items with today's, it also presents a comparison of the 1940 costs of water works facilities with present ones as an indication that water rates must be boosted. Designed to fit in a standard No. 10 business envelope, the booklet sells at prices ranging from 10¢ to 21¢ per copy. Imprints of your name and address as well as your rate per thousand gallons or cubic feet can be provided on lots of 500 or more. Ask for sample.

Willing Water Jewelry

Since their introduction in 1954, the Willing Water jewelry items have been most popular as awards, gifts, and good will builders. Presenting a blue-faced Willie in full stride, the emblem has made a hit as a lapel button as well as a decoration on a number of jewelry items. Included in the list of items now available are:

AW-1	Lapel Emblem (screw-back) ..... $ .75	AW-8	Shortie Tie Clip (rhodium plated alligator clip) $1.85
AW-2	Lapel Pin (joint pin & safety catch) ..... .75	AW-9	Money Clip (rhodium plated) 2.75
AW-3	Key Chain (spiral mesh chain and spring-lock holder) 1.25	AW-10	Cuff Links (rhodium plated disks) 4.50
AW-5	Zippo Cigarette Lighter (brush finish, boxed).... 3.15	AW-11	Earrings (screw type) 2.50

Willing Water Service Buttons

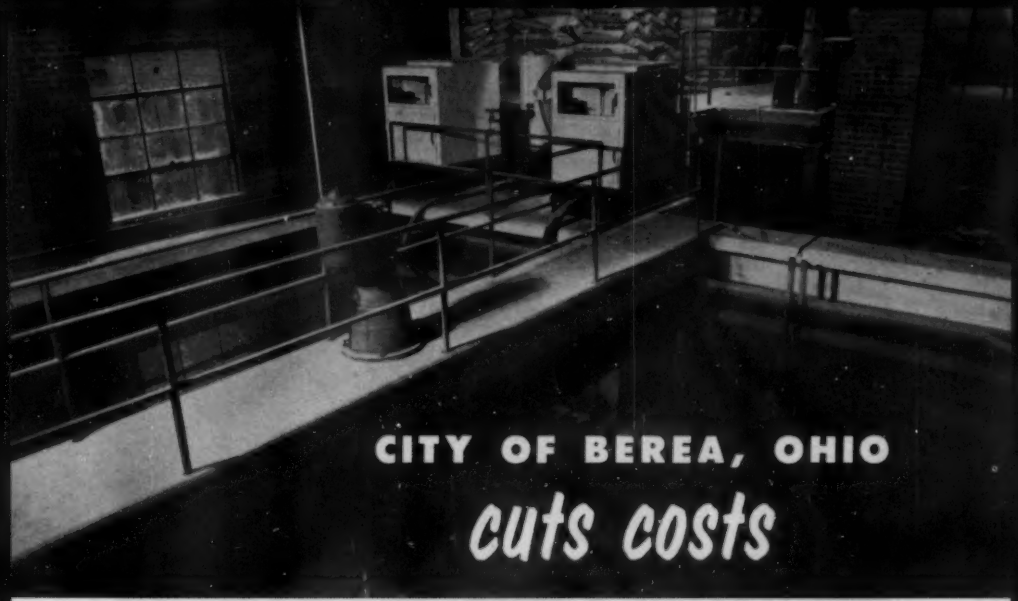
The popularity of Willing Water lapel emblems has led to the design of a special button for recognition of tenure. The design shown at the left was prepared on the request of the Alliance, Ohio, Water Department, which now uses the service buttons. It is now available to you, with your company name engraved on it. Minimum order is 25 buttons or pins. On such an order a die charge of $17.50 is made for inserting your company name. The pins (with joint pin and safety catch) or buttons (with screw-back) are priced as follows:

Bronze	$1.00	10K Gold	$5.25
Sterling	1.50	14K Gold	6.75
Gold filled	2.00		

The minimum quantity (25) may be assorted as to years of service and as to metal used. Please specify clearly the number of each type required with pins (for female employees) and with screw backs.

AMERICAN WATER WORKS ASSOCIATION

2 Park Avenue New York 16, N.Y.



CITY OF BEREA, OHIO *cuts costs*

New Cochrane SOLIDS-CONTACT REACTOR *combines*

mixing, precipitation, sludge concentration, clarification & softening

The relatively hard, turbid Rocky River supply for the city of Berea, Ohio, is quickly reduced in hardness to approximately 3.5 gr/gal and to a turbidity of less than 10 ppm by the Cochrane Solids-Contact Reactor shown above. An existing concrete basin 28′ square x 15′ deep was modernized by conversion to the Solids-Contact type. Using hydrated lime, soda ash and alum, the Reactor treats over 2,000,000 gpd at surprisingly low cost.

Because the design of the Cochrane Reactor provides higher quality treated water faster, in less space, with minimum chemicals, their use has grown tremendously for municipal applications. High slurry strength in the reaction zone speeds precipitation—there is very little waste water. Automatic desludging saves time and labor. In addition to softening and clarification, Cochrane Reactors remove color, taste, odor; reduce alkalinity, silica, fluorides, etc.

Cochrane's background in water conditioning makes possible the installation of complete systems under a single responsibility for continued, consistent performance. Write for Publication 5001-A and case history reprints.

Cochrane

CORPORATION

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NEW YORK • PHILADELPHIA • CHICAGO

Representatives in 30 principal cities in U.S.; Toronto, Canada; Paris, France; Mexico City, Mexico; La Spezia, Italy; Havana, Cuba; Caracas, Venezuela; San Juan, Puerto Rico; Honolulu, Hawaii; Malmo, Sweden; Santiago, Chile. **Pottstown Metal Products Division**—Custom built carbon steel and alloy products.

Cochrane also manufactures circular reactors

Demineralizers • Hot Process Softeners • Hot Zeolite Softeners • Dealkalizers • Reactors
Deaerators • Continuous Blowoff • Condensate Return Systems • Specialties

Where service begins -- LAYNE

Completely equipped work crew — backed by over 75 years of field experience.

A telephone call brings action—for the service facilities, know-how and experienced work crews of your nearby Layne Associate Company.

Layne service is based upon undivided responsibility from initial surveys and construction to operation and maintenance.

For service before, during and after well construction, look to Layne and your nearby Layne Associate Company, a member of the community it serves.

Write for bulletin No. 100 for more detailed information.

Layne

LAYNE & BOWLER, INC. MEMPHIS

General Office and Factory • Memphis 8, Tenn.

Layne Associate Companies throughout the world

Water Wells • Vertical Turbine Pumps • Water Treatment

INSTALL GATE VALVES UNDER PRESSURE!

- *in hydrant stubs to permit repairs*
- *where present valves do not work*
- *where additional control valves are needed*

Mueller® Inserting Valves are quickly and easily installed in any 4", 6" or 8" cast iron main. All operations are performed under pressure. Flow through the main is not interrupted and there is no loss of water.

The gate valve mechanism of Mueller Inserting Valves is identical to that of Mueller AWWA Gate Valves – in fact, the parts are interchangeable. Once installed in the main, Inserting Valves are operated like an ordinary gate valve.

Use Mueller Inserting Valves and Equipment to add the valves you need.

Use the new Mueller "CL-12" Drilling Machine to install all sizes of Inserting Valves faster than ever before.

Your Mueller Representative has full information on Inserting Valves and the new "CL-12" Machine. Contact him or write direct.

MUELLER CO.
DECATUR, ILL.

Factories at: Decatur, Chattanooga, Los Angeles;
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General Filter Company

WATER PROCESS ENGINEERS

45 SALES OFFICES

36 FIELD SERVICE DEPARTMENTS

AERATORS	SLUDGE SCRAPERS
SAND FILTERS	ZEOLITE SOFTENERS
DIATOMITE FILTERS	DEMINERALIZERS
LIQUID MIXERS	FLOTATION UNITS
FLOCCULATORS	DEAERATING HEATERS
CLARIFIERS	P.O.C. CONTROLS

GENERAL FILTER CO.

WATER PROCESS ENGINEERS

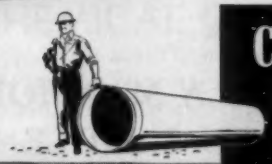
P. O. BOX 350 AMES, IOWA

The Swing IS TO CONCRETE PRESSURE PIPE FOR SEWER FORCE MAINS...

Here are some of the reasons why. Concrete Pressure Pipe not only is virtually permanent itself but also has permanently high carrying capacity. Pumping costs do not tend to rise over the years and lines do not have to be taken out of service for cleaning and scraping.

From an installation standpoint the joints in concrete pressure pipe are simple and easy to make up in the ditch. They are watertight, yet at the same time offer the advantage of enough flexibility to withstand changes in position due to settlement, misalignment or temperature variations.

More and more cities are swinging to concrete pressure pipe for sewer force mains as well as water mains. It will pay you to consider Concrete Pressure Pipe for your installation.



Concrete PRESSURE Pipe

AMERICAN CONCRETE PRESSURE PIPE ASSOCIATION
228 N. LaSalle Street
Chicago 1, Illinois

For Simplicity of Installation, Operation and Maintenance, SPECIFY . . .

CAN BE MOUNTED AS A MANHOLE METER OR WELDED SADDLE

The rugged, dependable Sparling 906 represents a new concept for meter installations. The 906 meterhead assembly is mounted directly on a standard AWWA flanged "T" or flanged manhole outlet for immediate operation . . . as a Welded Saddle Meter, it's furnished with a fabricated saddle permitting the meter to be mounted easily on an existing steel pipe. In saddle application, weight is reduced considerably and installation is simple. Sizes 16 to 72 inches.

OTHER OFFICES:

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Yes! ☐ We are interested in increasing our metering efficiency. Send us more information . . . no obligation, of course.

☐ Also send information on Sparling's line of Water Control Equipment.

Name .....

Company .....

Address .....

City ..... Zone ..... State .....

Send to: Sparling Meter Company
225 N. Temple City Blvd.
El Monte, California

USE NORTHERN GRAVEL
for
RAPID SAND FILTER

FILTER SAND SPECIFICATIONS are carefully laid out. The Effective Sizes and Uniformity Coefficients used by Consulting Engineers and also recommended by the American Water Works Association are the result of long years of research and experience.

The Northern Gravel Company is equipped to give you prompt shipment whether it be one bag or many carloads, exact to specification. Filter sand can be furnished with any effective size between .35 MM and 1.20 MM.

CHEMICAL QUALITY of the filter sand is also important. It must be hard, not smooth and free of soluble particles. This requires perfect washing, and grading facilities. We have every modern device for washing, drying, screening and testing.

FILTER GRAVEL supporting the Filter Sand Bed must be, in turn, properly graded to sizes calculated to support the Filter Sand, and be relatively hard, round and resistant to solution.

The new Northeast Station in the City of Detroit, recently completed, is one of the major projects included in the water department's expansion program. The Northern Gravel Company furnished 120 carloads of filtering materials for the 48 rapid sand filters incorporated in this plant.

Northern Gravel has no equal in facilities and our reserves of both sand and gravel are inexhaustible. Northern Gravel Company has been in business over 40 years. We guarantee uniformity of products and our records enable us to duplicate your requirements on short notice. Our location is central and we have commodity rates in every direction.

NORTHERN GRAVEL COMPANY

Muscatine, Iowa

P.O. Box 307 **Phone: Amherst 3-2711**

Impact Insurance Against

1—LOSS OF FIRE PROTECTION.

2—EXCAVATION AND PAVEMENT REPLACEMENT.

3—COSTLY REPAIRS INVOLVING MAJOR HYDRANT COMPONENTS.

4—FLOODING.

The Smith Protectop Hydrant is designed to permit rapid return to service at minimum cost when a Hydrant is damaged as a result of a traffic accident.

The Protectop Hydrant Standpipe and Valve Stem are equipped with *Special Couplings* located just above the ground. The Couplings withstand operating pressures and ordinary impact with an ample factor of safety. Under excessive impact occasioned by traffic accidents the Couplings fracture at the design points thus minimizing the damage and permitting speedy return to service at low cost.

All Smith Hydrants are equipped with Compression *Type* Valves which definitely eliminate flooding since the line pressure holds the Valve against its seat in the closed position.

Write for details.

38

THE A.P. SMITH MFG. CO.

EAST ORANGE, NEW JERSEY

here's what "out of sight out of mind" does to a water main

"Out of sight—out of mind" can be a mighty expensive philosophy in any water distribution system. The above unretouched photograph proves this point. It shows a badly tuberculated *eight inch* main whose *inside diameter was reduced to an average of almost 4.5 inches.* Resultant higher pumping costs with reduced pressure and carrying capacity make it costly to tolerate such conditions. That is why the savings effected in reduced pumping costs frequently pay for the *low cost* of National water main cleaning.

Since there's never a charge or obligation to inspect your mains, *call National now!*

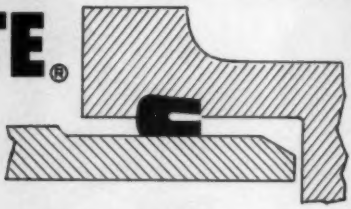
Call in National today!

NATIONAL WATER MAIN CLEANING COMPANY

50 Church Street • New York, N. Y.

333 Candler Building, Atlanta 3, Georgia; 920 Grayson St., Berkeley, Calif.; 115 Peterboro St., Boston 15, Mass.; 533 Hollis Road, Charlotte, N. C.; 8 S. Dearborn St., Rm. 808, Chicago 3, Ill.; P. O. Box 385, Decatur, Ga.; 2024 Merced Ave., El Monte, Calif.; 315 N. Crescent St., Flandreau, South Dakota; 3707 Madison Ave., Kansas City, Missouri; 200 Lumber Exchange Bldg., Minneapolis 1, Minn.; 510 Standard Oil Bldg., Omaha 2, Nebraska; 2910 W. Clay Street, Richmond 21, Va.; 502 West 3rd South, Salt Lake City 10, Utah; 204 Slayton St., Signal Mountain, Tenn., 424 S. Yale Avenue, Villa Park, Illinois; 7445 Chester Avenue, Montreal, Canada; 576 Wall Street, Winnipeg, Manitoba, Canada; Apartado de Correos No. 5, Bogota, Colombia; P. O. Box 531, Havana, Cuba; Marquinaria, Apartado 2184, San Juan 10, Puerto Rico; Bolivar 441-A, Marafi., Lima, Peru.

FLUID-TITE® JOINT



VALVES & HYDRANTS FOR "CENTURY" ASBESTOS-CEMENT PIPE LINES

Specify FLUID-TITE* end-connections on M&H valves or hydrants ordered for installation with Class 150 "Century" asbestos-cement pipe. The hub ends of this valve or hydrant are especially designed to accommodate the FLUID-TITE gasket, and seal the joint when the end of a "Century" asbestos-cement pipe is inserted (see cross-section sketch of joint above).

No special fittings or extra joint materials are required. The only joint accessory is the gasket. Installation is simple and easy. Unskilled workmen can assemble the joint.

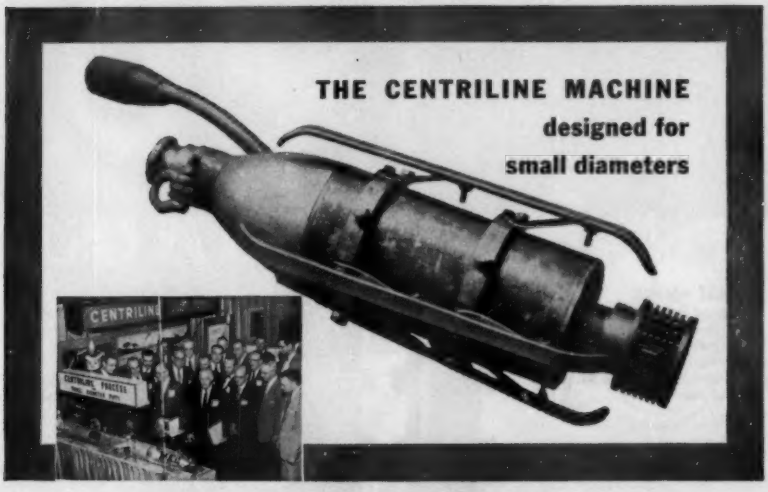
Either conventional or "O"-Ring stuffing box is available on M&H FLUID-TITE joint non-rising-stem gate valves. Wire or write for complete information.

*Registered trademark for Keasbey & Mattison Co.®

M&H VALVE AND FITTINGS COMPANY
ANNISTON, ALABAMA

SUBSIDIARY OF WALWORTH

Centriline's conversation piece at the A.W.W.A. convention



Excitement ran high. Crowds thronged around the Centriline booth, eager to see and inspect this revolutionary new development for relining small diameter pipes in place. For years, large mains have been renewed by the famous Centriline Process of centrifugally applying a cement-mortar lining which permanently prevents future tuberculation, corrosion and leakage. Now, with the introduction of the new small diameter Centriline machine, every city's important transmission and distribution lines from 6" to 14" can also enjoy the same money saving protection. The new Centriline machine has a design feature which eliminates excavations at valves, laterals and corporation cocks. Through Centrilining, the pipes in your system regain their original flow capacity and pressure . . . pumping and maintenance costs are reduced and the line's life is extended indefinitely. Centrilining accomplishes all this with a minimum of interruption to surface traffic, since the pipes are lined in place. Send today for your copy of our illustrated brochure which fully describes how Centriline can help you salvage worn out lines of every size.

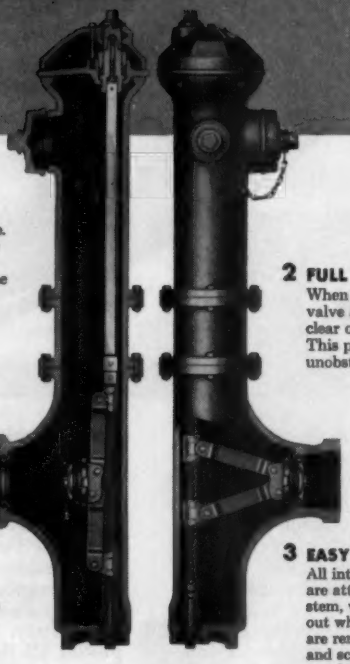
CENTRILINE CORPORATION

A Subsidiary of Raymond International Inc.

140 Cedar Street
New York 6, N. Y.
WOrth 2-1429

Branch Offices in Principal Cities of the United States, Canada and Latin America.

Here is why farsighted city officials install IOWA fire hydrants



1 FAST WATER
Opens fast, with the pressure. Closes slowly, without water hammer. Sticks, stones or foreign matter cannot become lodged between the valve and valve seat.

2 FULL FLOW
When hydrant is fully opened, valve and stem are entirely clear of the waterway. This permits free and unobstructed flow of water.

OPEN

CLOSED

IOWA HYDRANTS AND VALVES
meet all A.W.W.A. specifications

3 EASY MAINTENANCE
All internal working parts are attached to the valve stem, which is easily lifted out when dome and head are removed. Common wrench and screwdriver only tools required. No special tools are needed.

Let us send you details on Iowa's complete line of valves and hydrants

IOWA
VALVE COMPANY
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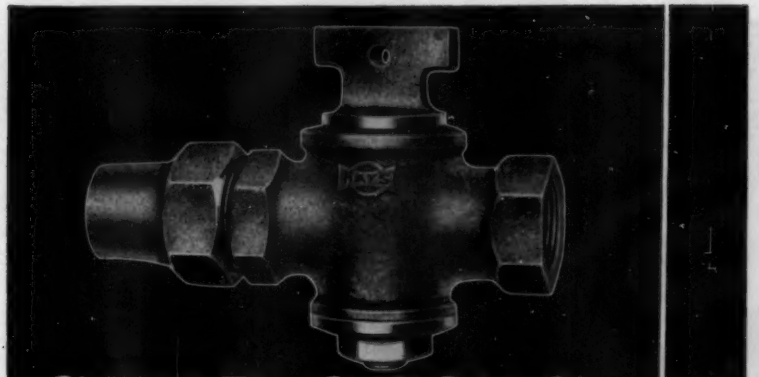

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Economic Aspects of Public Water Utility Construction

Jerome W. Milliman

A contribution to the Journal by Jerome W. Milliman, Asst. Prof. of Agricultural Economics, Univ. of California, Los Angeles, Calif.

THE purpose of this article is to explore briefly, yet in a fundamental way, some of the economic questions which should be taken into account when the formulation and operation of public water projects are being considered. The author does not intend to supply ready answers or to draw definite conclusions, but rather to show that these questions must be raised and answered if intelligent and efficient decisions are to result. Parts of the analysis presented in this article appeared in an earlier paper by the author (*1*).

The author is distressed that many of the economic facets of water project planning have received to date only the most sketchy sort of consideration and study, and is at a loss to explain why such is the case. The net result is that questions turning on legal issues of water rights and engineering questions of design, capacity, and location have been given extended discussion, while economic issues of primary importance have been almost totally neglected. Yet, economic principles have an important bearing on both the legal and engineering issues, as well as being important in themselves.

Although it may be agreed that the final decisions in regard to public projects may be political in nature, rather than economic, it seems evident that sound economic analysis is always needed so that the costs and effects of actions can be clearly weighed. The economist, however, has yet to be admitted as an equal partner in the project-formulation process. Rather, he seems to be limited to justifying and checking on decisions already made. All too often, the economist is expected to rationalize existing decisions rather than to explore the problem in its entirety. As long as basic economic questions are given scant treatment, public

water projects will be subject to the serious criticism of failing to make the best use of economic resources.

Water as a Resource

Perhaps part of the neglect of economic analysis in planning public water projects stems from a widespread belief that water as a resource is something holy or sacred. There is a feeling that water as a resource is something unique and that the traditional economic principles of resource allocation do not apply to it. Many intelligent laymen, who think rationally in terms of the best use of land, and the best development and provision of natural gas, petroleum, or electricity, are apparently willing to abandon economic analysis in water development.

Most economists would agree, however, that water as a resource or a factor of production has no unique qualities which should cause it to be treated differently than any other resource. Any attempt to single out water resources for special economic consideration may result in error.

Although it is true that a particular area may lack a cheap water supply, it should be remembered that additional water can always be supplied if the return will cover the extra costs of the supply. The same standard is used for electricity, natural gas, or petroleum, in areas or communities which need extra amounts of a resource or factor of production. Although the institutional pattern of ownership, especially as concerned with the commonality of exploitation, may call for attention, the use of water at any time and place should be considered within the framework of the general economic principles of resource allocation.

The fact that public control and development of water resources are often necessary does not mean that the principles of economic efficiency should be abandoned. It is impermissible to assume, for example, that an area has certain requirements for water which must be satisfied by public projects without consideration of the relation between costs and returns. Economic demands always depend upon price, and price in turn must be based upon the costs of the water at the point of delivery. Provision of water to users who cannot cover the costs is subsidy pure and simple and must inevitably result in a redistribution of income and a reduction of total productive efficiency.

All of this sounds convincing enough to the author, but the common reaction to this argument is: "Water is different, because without it we would all die of thirst!" It is implied, therefore, that special economic treatment for water is justified after all.

To that sort of reasoning the author will reply on three levels:

1. It is true that water is necessary to life, but the same is also true of many other resources.

2. Although the first units of water consumed have very great values, the marginal utility or marginal productivity of succeeding units always declines.

3. It is not a question of having some water or none at all. When the issue of new water projects is being considered, it is always a question of a little more or a little less water. The question is always a marginal one, so the returns from extra water must be compared to the returns from all of the alternative ways to use scarce resources, in public and private uses.

Strictly speaking, the cost of building a water project is the sacrifice of the value or returns the same resources could earn in alternative uses. Not to insure that the returns cover the costs is to use resources inefficiently. Simply stated, what is wanted is full returns for the money spent on water, just as for any type of expenditure.

Despite the fact that water may be priceless in an absolute sense, just as many other resources are, the question is never an absolute one but rather a marginal one. And at the margin, water is not priceless.

Although it is often argued that: "It is wrong to waste a single drop of our precious water," the real waste, in a meaningful sense, occurs when the costs of providing water (or any other product) are greater than the returns from doing so.

Examination of Statements

With the foregoing background in mind, the author would like to examine some of the statements which are widely used to justify certain kinds of action in the public development and use of water resources. The economic implications of these statements and the ultimate consequences to which they might lead should be studied.

1. *The waters of the state belong to all of the people of the state.* What does this statement mean within the context of a society based upon private property? Does it mean that water production is to be socialized? Why is water singled out for special treatment? Similar reasoning could be used to justify state control of all resources. Would it be said, for example, that all of the land or petroleum of the state belong to all of the people of the state?

2. *The water resources of the state must be distributed fairly and equally with benefit to all* (*2*). The major question, of course, is what is fair? Who is to say? Does fairly mean abandoning economic principles? Also, what is meant by distributing water resources equally? Does equally mean according to population, area, ability to pay, or need? How does this slogan take into account the concepts of private property and economic efficiency?

3. *The state should participate in water resource decisions to effect a balanced use of water for all purposes* (*2*). What is a balanced use, and when is water use not balanced? Again, who is to say what is balanced: a central water board, a political body? Does a balanced-use concept mean that water will not be allocated to its most productive use? Should the relation between returns and cost be ignored?

4. *The state should construct or financially aid a water project wherever there is a need for a project which cannot be met within a reasonable period of time by entities other than the state* (*2*). If by need is meant an economic demand then the author would have little objection. But need for water is often used with no reference to the question of whether the users can cover the costs. Some people apparently feel that the state has a moral obligation or duty to see that there is enough water provided at all times for all uses, apart from costs and prices. The same logic could be used to justify public production and subsidy for any commodity.

Water Subsidies

At this point the question of subsidy which is implied in some of the above

statements should be explored in greater detail.

Many public authorities apparently recognize that future water projects in California will be relatively expensive, and it is sometimes openly admitted that the water users may not be able to bear the costs. It is occasionally urged, however, that the water projects should be constructed anyway and paid for out of general tax contributions, or other public funds, on the ground that the whole state benefits from the increased water use. There seems to be an underlying feeling that more water use is better than less, even though the users cannot bear the cost.

An example of this type of reasoning appears in the following statement by a public official (*3*):

> . . . From here on out, the cost of these projects is going to appear so great, that if you try to assess it only on repayment, and repay this cost plus the bond issue by charges against just the water and power user, you simply can't build the projects. But if you take the broad viewpoint that this project is necessary for the economy and growth of the whole state of California, then we have to go back to the figures we were given . . . , where a couple of millions of gallons of water is worth a couple of millions of dollars to a city, because the dollars made out of agriculture is what makes the wheels go 'round in the state. When our economy revolves three to five times, and every irrigated acre of land will earn $200 in new money, then it becomes a proposition where the earning power, or the purchasing power, created by this water wealth, will create 100,000 jobs a year at the cost of $5,000 a year.

This is very puzzling to an economist. Are costs of no consequence? Such reasoning seems to throw the gates wide open to any kind of expenditure, not just water projects. It must be realized that all expenditure benefits somebody. It is granted that project dollars are respent creating additional income; what is neglected is that the tax dollars to pay for the project would also have been respent if left in the taxpayers' hands. It is forgotten that money costs are always borne by someone, and that the payment of water costs from tax proceeds results in a redistribution of income from the taxpayers to the water users. As far as real costs are concerned, the use of resources in water projects which cannot cover costs may well mean that greater alternative production is sacrificed somewhere else, causing a reduction in real income.

It should be stressed that this same logic applies with equal validity to all subsidies, regardless of whether they are met by the use of general tax contributions, from oil revenues, or from a "rainy day" fund.

It appears to the author that this question of subsidy of water costs by taxpayers, or by other means, is a matter which should be brought into the open and examined carefully. Of course, if after all of the facts are known, the electorate still wants to produce water in this manner, then the economist can say little more. The fact of the matter is that much of the discussion concerning water projects does not examine or even recognize this crucial economic question.

California Water Plan

This article has dealt with state water planning in terms of general principles; it might, therefore, be interesting to look briefly at some of the particular facets of the California Water Plan and the Feather River Project. Here again, the author views

his role as an economist as one of asking the economic questions which will provide a broader basis for decision-making on the part of public officials and the electorate. The author's statements are not intended to be viewed as partisan support for particular water interests.

The California Water Plan purports to formulate an outline "for the orderly development of the state's water resources to meet its probable ultimate requirements." Economists have criticized both the concept of ultimate and the concept of requirements as having little economic meaning. Who can specify ultimate water use at some vague future date when all that is certain is that economic changes will take place? The so-called requirements were computed by assuming the price of water to be zero or irrelevant. By this method the irrigation needs of the Sahara Desert could be computed, but the result would not be very meaningful in itself. Much of the contemplated use attributed to California desert and mountain region in the plan is in the same category.

State water officials, in reply, point out that "economic and financial tests must be made for each project of the plan as the projects are proposed for construction" and that the plan does not attempt to do this (*2*). While this reply is a valid one, it should be recognized that it merely supports the viewpoint of economists that the requirements set forth in the plan have little or no relation in themselves to present or expected economic demands for water. As such it is not valid to solicit public support for state water projects based upon these so-called requirements as is often done.

It would seem to be almost rudimentary that the economic feasibility of a project should be carefully determined before it is approved and constructed. Careful consideration of the economic merit of a proposed project seems to require that: [1] total benefits exceed total cost (both in terms of present value); [2] there are no alternative projects with higher net present values; [3] assessment of benefits for repayment, and the form of repayment, whether by rates, taxes, or fees, be made clear to all parties at the time the economic feasibility is determined. Once a project is built it is too late to worry about its economic feasibility. A similar position is taken by S. V. Ciriacy-Wantrup (*4*).

Feather River Project

With regard to the Feather River Project, it is perhaps shocking that this project, which promises to be the most costly water project in the history of the world, has yet to receive an extended cost-benefit analysis, despite the fact that it has been actively considered since 1951. Only a quarrel over water rights, in fact, prevented it from receiving legislative sanction at the last session of the legislature. The economic feasibility of the Feather River Project has yet to be determined.

Although both the Bechtel report (*5*) and the state reports (*6*) have declared the Feather River Project to be financially feasible, a study of this point discloses that both studies are concerned with the question: can the project be paid for? The answer to that question is clearly yes, if tax contributions or subsidies from other sources are included. It could be pointed out that almost any project could be declared financially feasible on similar grounds.

According to the state report, revenues from the sale of water and power

will not be sufficient, even as assumed, to cover annual costs until 1997, some 38 years after original construction. Approximately $496,000,000 of funds from general tax contributions will be required to cover costs during that period (*6*). Although by the year 2026, total project revenues will exceed total project costs, it is important to note that the bulk of the costs occur early and the bulk of the revenues occur later.

An important consideration from an economic standpoint would be the present value of these revenue and costs streams. DeHaven and Hirshleifer (*7*) found, using figures from the Bechtel report (*5*), that with a discount rate of 2.7 per cent the project as a whole had a net value of minus $162,000,000. At a discount rate of 5 per cent the present value was calculated to be minus $519,958,000.

In addition to the lack of overall cost benefit analysis, many economists are concerned with the point that the specific returns and costs for the Feather River water may need additional scrutiny. For example, the state report calculates that in the 15-year period from 1976 to 1990 when the Southern California load for Feather River is building up, approximately $729,000,000 worth of water will be sold in Southern California at prices averaging $45 per acre-foot. By contrast, the Metropolitan Water District in its first fifteen years of operation from 1941 to 1956 was able to sell only $30,000,000 worth of Colorado River water at much lower water prices. Prices in the neighborhood of $45 per acre-foot at the wholesale level will undoubtedly have some check on demand. Careful study would seem to be called for, particularly when the Feather River water is a supplementary supply. The author suspects also that adequate consideration has not been given to the cost of developing alternative water supplies, such as the reclamation of waste waters.

In regard to the costs of the Feather River Project, it is not usually recognized that the project will require far more electric power than it will produce, and that the cost of power will be a primary element in the operating cost of the project. The power requirements for the High Line route are some five times the power capacity at Oroville Dam so that approximately 7.6 billion kwhr a year will have to be secured from outside sources. This amount is almost double the output of Hoover Dam. Apparently, care must be exercised that, in dealing with a water shortage, a power shortage is not created.

As far as the Oroville Dam is concerned, the Bechtel report (*5*) estimates that the cost of installed capacity there may run as high as $950 per kilowatt if all of the costs are allocated to power. This figure is many times the cost of a thermal-electric plant. Evidently over three-fourths of the cost of the dam, reservoir, and power plant must be allocated to flood control and water supply in order to bring the remaining capacity costs down to a reasonable level for competitive hydroelectric production (*5*).

The author's rough calculations show that it will take approximately 5,000 kwhr to pump 1 acre-ft of water through the 3,400-ft pump-lift over the Tehachapi Mountains to Southern California, as specified by the High Line route. Can this energy be supplied by the purchase of cheap off-peak power? Even at a rate of 5 mills per kilowatt-hour, the power costs just for

pumping Feather River water into Southern California may approximate $25 per acre-foot. This merely emphasizes that the Feather River water will be expensive, no matter how the costs are calculated or who pays them.

Conclusion

Perhaps the author has said enough to support his principal theme: that economists are concerned with the fact that state water planning has not given sufficient attention to the economic questions involved.

It is not the author's purpose to say that the Feather River Project, or any other water project, should or should not be built. Rather, the author has tried to demonstrate that many important economic issues must be explored if intelligent decisions are to be made regarding public water development. There is nothing unique about water projects which justifies neglect of careful economic analysis.

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Research and Experiments in Evaporation Reduction

Uel Stephens

A paper presented on Apr. 21, 1958, at the Annual Conference, Dallas, Tex., by Uel Stephens, Director, City Water Dept., Fort Worth, Tex.

THE study of water loss due to evaporation is not new. Neither is the observation that evaporation can, to some extent, be controlled by placing a thin film or coating over the surface of water. Certain effects of thin films of oil on water surfaces have been known for at least 2,000 years. Mariners for centuries made use of this phenomenon to calm stormy seas. The increasing demand of modern civilization for more water, coupled with the most drastic and prolonged below-normal rainfall and runoff conditions on record in the Southwest, gave impetus to the study of ways and means of conserving water supplies and making better use of the available water.

Previous Research

As early as 1917, Irving Langmuir published data on his findings in the field of evaporation reduction (*1*). Ten years later, with D. B. Langmuir, he published further results of research in this field (*2*). These studies may be considered as the real beginning of the scientific investigation of how the evaporation of water may be controlled by placing over the exposed surface a thin film or covering. Since then much work has been done by Mansfield in Australia and by the British in Kenya, East Africa. The Southwest Research Institute really became interested in the field as the drought, which began in 1951, became more and more acute through 1955.

Preliminary Steps

On Dec. 1, 1955, a full 1-day meeting, attended by representatives of thirteen interested organizations, was held at the Southwest Research Institute offices in San Antonio, Tex. By this time the drought condition in the Southwest had continued to increase in severity. Due to the mass of convincing factual information presented by Louis Koenig and other officials of the institute, a committee was appointed to determine whether a research project on the subject of water evaporation control should be undertaken and if so, whether the estimated cost of $20,000 for the first 18 months of work could be financed. The committee, known as the Finance Committee for Reservoir Evaporation Control Research, was under the chairmanship of E. V. Spence; the author served as secretary-treasurer.

The first committee meeting was held on Dec. 11, 1955. A successful fund-raising campaign was organized and conducted. Municipalities, private industry, especially the private electric utilities, consulting engineers, and organizations such as the AWWA, were not only keenly interested in the pro-

posed program, but backed up their interest by contributing, to date, the sum of $44,110 for carrying on the research program, which is now in its third year. The funds contributed were deposited with the Texas State Board of Water Engineers, which acted as the contracting agency with the Southwest Research Institute. All funds have been used for the actual expense of the research work.

Program

In the initial conference statistical data were presented indicating, among many basic facts, that annually in the Southwest as much as 10 ft of vertical water depth may be lost through evaporation, while rainfall in these areas may be less than 10 in. In many areas the amount of water evaporated from municipal surface supplies exceeds the amount put to beneficial uses. The loss of water by evaporation could be controlled by the following methods:

1. Construction of storage reservoirs with maximum average depth and minimum exposed-surface area
2. Concentration of water into single storage reservoirs
3. Elimination of marine growth
4. Elimination of shallow areas
5. Storage of water in underground reservoirs (recharged underground aquifers)
6. Reservoir roofs, floating covers, sealments
7. Windbreak construction
8. Monomolecular film applied to water surface.

The remainder of this article will discuss the research and experiments dealing with monomolecular film.

The original research program outlined by the Southwest Research Institute was designed to provide for all interested parties authentic information on the following subjects:

1. Status, as of 1956, of developments by others, determined by a comprehensive search of the literature and a complete bibliography.
2. Best compounds to be used
3. Best methods of application
4. Technical and nontechnical explanations of how the film works
5. Coverage and life of the film
6. Biological effects
7. Effects on physical objects in the water, such as bathers, livestock, and others
8. Effects of physical factors such as water temperature, rain, dust, freezing, wave action, and bacterial action
9. General effectiveness of the film treatment
10. Cost of treatment
11. Suggested methods for application to large reservoirs.

This schedule of expected accomplishments was considered by the finance committee to be acceptable, and as early as January 1956 the program was commenced and rather widespread publicity was given to the basic research work to be carried on. By September 1956 the institute's plans and accomplishments were developed as the following five-phase program:

Phase 1. A complete bibliography was to be compiled relative to water evaporation and its control. This was to include theory, methods, suitable means of application, techniques for evaporation measurement, and all obtainable results of work to date.

Phase 2. a. Preliminary laboratory work in the screening of organic chemical samples that may be applicable in evaporation control was to be undertaken. As of Sep. 1, 1956, over 146 different samples had been submitted by individual companies for testing.

The samples were of a great variety of materials, such as alkanols, organic acids, amines, amides, ketones, silicones, diols, and others. Some of the samples were not pure compounds, but were complex mixtures, such as preparations from the treatment of oils and fats (tallow), and inert materials such as ground plastics, plastic bubbles, ground cork, plastic air pillows and membranes, and a wide variety of others.

b. A fundamental study was to be made of the physical chemistry of monomolecular films and chemical substances that are suitable, with the objective of correlating molecular structure or physical properties with their effectiveness as water-evaporation retardants.

The major part of the biological work was to be done by the USPHS. This included tests for toxicity of the chemical compounds to be used, their effect on marine, animal, and plant life, their effect on oxygen and carbon dioxide transfer rates between air and water, and similar studies. Under the direction of Bernard B. Berger, work is also under way at the Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio (*3*).

Phase 3. Concurrently with the laboratory screening tests, evaluation of hexadecanol and other materials showing promise in the screening work was to be made in 10-ft stock tanks. This phase was intended to evaluate in a preliminary way the performance of the film under field conditions. In addition to providing a further screening of evaporation retardants showing promise in the laboratory, this phase was also expected to provide a technique which can be used on similar tanks on ranches and farms, after the toxicological effects of the material or materials used have been investigated. Climatic effects, methods of application, life expectancy, and other factors, can be explored further during this phase.

Phase 4. This phase of the work was to be similar to Phase 3, except that the work would be performed on a larger scale, in swimming pools, and in ponds and reservoirs up to 5 acres in size. Those compounds showing the most promise in Phases 2 and 3 were to be further evaluated. At this stage the cost and economics of the process could be calculated with some reality. A large part of the work of this phase was to be conducted in cooperation with the US Geological Survey, Denver, Colo., under the direction of G. E. Harbeck Jr.

Phase 5. As the final step in the program, as outlined, it was planned to present a schedule of tests and a program for treating large reservoirs (several hundred acres to several square miles). This could be done only after full clearance has been obtained from local, state, and federal agencies, such as local health departments, fish and game commissions, state health departments, the USPHS, the US Food and Drug Administration, and others, and including assistance from the US Bureau of Reclamation and the US Geological Survey. Thus, large bodies of water, particularly those used by animals or humans as drinking water sources, were not to be used in the testing program until all possible deleterious effects had been eliminated.

The original program was planned to be completed in 18 months, beginning Jan. 1, 1956, and was estimated finally to cost $25,000. The program did not include applications to reser-

voirs larger than 2–3 acres of surface area. Progress reports were to be submitted about once a month, and as a part of the program there was to be prepared for distribution a final report.

Program in Action

One of the outstanding features of the program was the holding in San Antonio, Tex., Apr. 14, 1956, of the First International Conference on Reservoir Evaporation Control. The proceedings of the conference are available (*4*). Among the 75 who registered and took part in the program were such outstanding authorities as: V. K. LaMer, Professor of Chemistry, Columbia University; W. W. Mansfield, Senior Research Officer, Division of Industrial Chemistry, Commonwealth Scientific and Industrial Research Organization of Australia; H. G. Hanson, Director, Robert A. Taft Sanitary Engineering Center; S. W. Freese, Consulting Engineer; E. G. Nielson, Assistant Commissioner, US Bureau of Reclamation; G. E. Harbeck Jr., US Geological Survey; and I. Deschamps, Mexican Institute of Technological Investigations.

From the inception of the program it was agreed that certain federal agencies were in the best position for some phases of the work. Accordingly, the US Geological Survey, through the Denver office, offered to make all official water-level observations and records to measure the amount of evaporation. Throughout the entire program G. E. Harbeck Jr. has done this part of the work, using the energy-budget method rather than the standard plan procedure for determining the evaporation.

The USPHS, through the Taft Sanitary Engineering Center, expressed a desire to work with other federal agencies in determining the feasibility of this approach to water conservation. Its contribution covered the following aspects of film production materials: [1] human toxicity potential, [2] effects on fish, [3] effects on water treatment processes, and [4] resistance of film to biological attack.

Laboratory Work

The early laboratory work demonstrated that the most effective compounds and the ones which most nearly met all requirements of health standards were octadecanol, dodecanol and hexadecanol (cetyl alcohol). The latter appeared to offer the best possibilities. While the laboratory screening of samples continued until over 160 separate compounds were tested, the outdoor and field pond experiments were confined to hexadecanol and, to a limited degree, dodecanol. Hexadecanol without admixtures is the only compound which has been approved by the USPHS for use on public water supply reservoirs.

The laboratory apparatus used by the institute was complete and extensive. Testing of such a large number of samples with single apparatus would have been extremely time-consuming. A battery of eighteen jars and a chemical-feed apparatus were used to enable the testing of eighteen samples simultaneously (Fig. 1).

Field Work

Overlapping the laboratory phase of the program were the outdoor experiments carried on by use of two 10-ft diameter metal stock-watering tanks (*5*). One tank was used as the control without surface treatment while the second tank was used for the ex-

perimental work. The tanks were located on the grounds of the institute, well away from buildings and other features which might create wind or unnatural atmospheric conditions. Regular tap water was used in the experiments.

The best evaporation retardants have shown reductions in evaporation of as high as 93 per cent for short periods, and 15–50 per cent for 15 days in the laboratory under ideal controlled conditions, but for only 1–2 days in field tests. In fact, the evaporation returned to almost normal after 5–8 days. The disappearance of the film in a relatively short time was traced to a bacterial action which was effectively controlled by mixing with the film-forming hexadecanol a small quantity of copper sulfate. USPHS clearance of this mixture has not been secured, however, and its use in large quantities in a public water supply is not favored.

The final phase of the field work was carried out on several small lakes, one of which was the Essar Ranch Lake (Fig. 2), a small ranch pond located some 16 mi southwest of San Antonio, Tex., where all conditions of inflow, outflow, temperature, atmospheric, and other natural and artificial conditions could be carefully observed and measured. For these experiments the US Geological Survey Denver office, under the personal supervision of G. E. Harbeck Jr. made all water level, evaporation loss, and other necessary observations and measurements to assist in determining the effectiveness of the applied monomolecular film. Hexadecanol was used in granular forms, and was applied by use of floating rafts. These experiments, which were begun on Jun. 22 and discontinued on Oct. 31, 1956, indicated a possible evaporation reduction as high as 18 per cent. They also brought out three disturbing elements which had

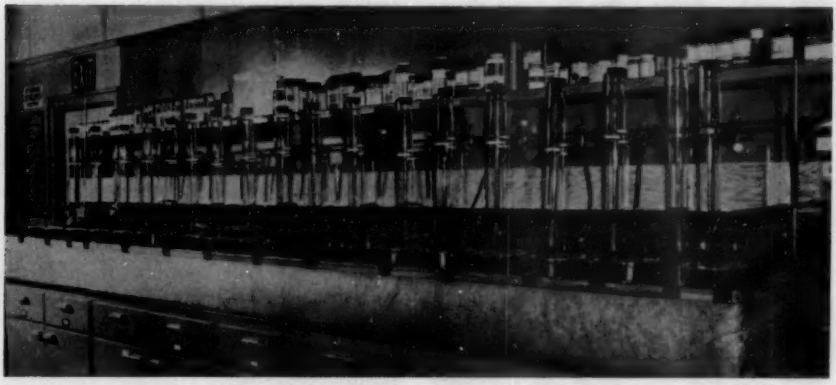

Fig 1. Screening Apparatus

This apparatus was used by the Southwest Research Institute in determining in the laboratory the effectiveness of various chemical compounds as evaporation retardants. More than 160 separate samples were tested.

not previously been reported: [1] confirmation of the destruction of the film by some unidentified bacteria which seem to exist in all open-surface reservoirs in the Southwest, [2] drifting of the film due to wind and wave action, and [3] very doubtful possibilities of developing a raft or float method of applying a compound in granular form.

Phases 1, 2, and 3 of the program appear to have been carried on as far as is necessary, and have been terminated. Phase 4 was extended to include experimental work on small surface reservoirs or ponds at the following locations, all in the state of Texas: Cement Lake, Fort Worth (2 acres); Bluff Lake (Texas Gulf Sulphur Co.), Liberty (20 acres); Rio Farms, Hidalgo and Willacy counties; Rowe Lake, Hondo; Callaghan Ranch Lake, Briones Lake, Mendoza Lake and Dryden Lake, Laredo; Flying W Ranch Lake, Cotulla.

In these later experiments several evaporation-retardant compounds * were used with varying degrees of success. So far as the author is aware, none of these compounds has been cleared for use on public water supplies by the USPHS, so he is not in a position to advocate their use at the present time.

USPHS Clearance

Carrying on a research program is necessarily time-consuming and expensive; it requires endless patience and often is beset with obstacles which may be insurmountable. When the problem involves factors which may affect public health and welfare the problems become all the more complex. Thus, it appears fitting to discuss in this article at least one of the health problems which the project involved.

In the beginning, it was decided that since the project involved public water supplies, before any chemical or compound would be recommended for use as an evaporation retardant, it must be unconditionally cleared through the USPHS. Accordingly, samples of compounds offering the best possibilities were submitted to the Taft Sanitary Engineering Center, and in due course an acceptable clearance of hexadecanol was received. This clearance was specifically limited to the one compound. The clearance did not cover hexadecanol to which a small amount of copper sulfate, for example, had been added to act as a bactericide. Each specific substance had to be cleared separately and for each such clearance months of time might be required. This procedure is necessary, and the research council offered no objection to it. It is cited only to illustrate one of a number of details which must be carried out in a research program such as the one under discussion.

Summary of Accomplishments

The accomplishments of the more than 2 years of work in the field of water evaporation reduction carried on by the Southwest Water Evaporation Research Council may be summarized as follows:

1. Research work began in January 1956 and is being phased out as a private venture in the spring of 1958.

2. Contributions of funds from private and public sources amounted to $44,110. No part of this sum has been paid to or spent by any member of the council for carrying on the program.

3. The original finance and steering

* LOROL 7, SIPONOL L5X, ADOL 10 and ADOL 11, SIPONOL EGH, EVAPORTROL, and possibly others.

committees ceased to function when the Southwest Water Evaporation Research Council was organized and incorporated as a nonprofit research organization Aug. 13, 1957, and assumed all of the duties, responsibilities, assets, and liabilities of the two committees. Some of the officials of the council are: E. V. Spence, president; A. P. Hancock and H. R. Drew, vice-presidents; and the author, secretary-treasurer.

5. The Southwest Research Institute believes that sufficient laboratory work has been done to establish the fact that by application of a monomolecular film to a water surface evaporation can be reduced by more than 30 per cent, and that compounds which offer the most promising results are members of the fatty alkanols group. The most promising of these is hexadecanol, a waxy compound having sixteen carbon atoms

Fig. 2. Essar Ranch Lake

This photograph shows staff gages in the left foreground, the surface temperature recording thermocouple raft in the center, and one of the eight hexadecanol-dispensing rafts in the right foreground.

4. The research program initiated in 1955 generated almost nationwide interest, and served as the spark plug to cause other groups to initiate similar research programs. One of these groups is the US Bureau of Reclamation at Lake Hefner, Oklahoma City, Okla., and near Denver, Colo. Numerous private experimenters have instituted projects and developed compounds and techniques for which great claims are made but which have not yet been officially authenticated.

in a straight-chain configuration. Hexadecanol is commercially available at reasonable costs.

6. Sufficient laboratory work has been done to establish that certain chemical compounds related to natural fats and oils have the property of spreading over water in a thin film of monomolecular thickness. Fatty acids and fatty alcohols of the C_{12}-C_{20} carbon chain length are typical. These compounds have in their configuration of atoms an OH (hydroxyl) group end

of the molecule. This group, being identical to such a group contained in the water molecule, stimulates an affinity between one end of the molecule and the surface of the water. The result is an alignment of the fatty film molecules, standing on end perpendicular to the water surface, and closely packed. This phenomenon has the effect of retarding water vapor tending to escape from the surface, and thus reducing evaporation so long as the molecules so aligned and arranged are compressed and held together.

7. Practical and economical application methods and simple, inexpensive apparatus for applying and maintaining a monomolecular film on small ponds can be developed and put on the market by private enterprise within the next few years. The greatest benefits which will result from the research work will be to the ranchmen and farmers, by reducing the water loss due to evaporation from the surface of the millions of small ponds which have been and will be constructed.

8. Before techniques are developed for practical application to large water surfaces (more than 1,000 acres) additional research must be carried on. Some of the fields worthy of further study are: application by crop dusting planes and helicopters; slurry applied by force pumps, wind-, gas- or electric-driven; motorboat distribution; hand broadcasting from the windward shore.

Future Plans

This article should not be concluded without discussing briefly plans for carrying forward the research work, which so far has been financed by contributions made by those interested in the program. The research work carried on at the Southwest Research Institute is considered by the council as having been entirely satisfactory; it has accomplished the original objectives, and the financing has been eminently successful.

Due solely to the fact the available funds are now virtually exhausted, the program will be closed out in June or July 1958 with the submission of the final report. The final report of the institute will, upon approval by the council, be combined with reports of the US Geological Survey and the Texas State Board of Water Engineers and printed in preliminary report form by the Geological Survey and distributed.

The last special session of the Texas legislature in 1957 made available to the Texas State Board of Water Engineers up to $25,000 to be spent on evaporation research during the next 16–18 months. Thus, it appears that the Texas legislature recognized that the program held such great promise for public benefit that it was willing to provide public funds for carrying on the work.

The State Board of Water Engineers has requested the Southwest Water Evaporation Research Council to continue as a functioning organization and to assist the board in transferring the research program to the Texas A. & M. College Research Foundation, which is ideally suited to carry the work on in both the laboratory and the field.

The A. & M. Research Foundation now has available a ranch of 11 sections, amounting to about 7,000 acres, located in Throckmorton County, Tex., for the purpose of carrying on large-scale research work in ranch management. Stock ponds and all other facilities are available on the

ranch for all kinds of research work. The college officials, and especially Archie Kahan, director of the research foundation, have indicated a sincere interest in the program and it is expected that the research program on a large scale will be under way within the immediate future.

Conclusion

It is the Southwest Water Evaporation Research Council's considered opinion that ways and means will be developed very shortly for applying a monomolecular film to the surface of small stock and farm ponds which will reduce the water loss due to evaporation as much as 40 per cent, and that the process will be simple and economical in its application and maintenance. There are still many questions to be answered before satisfactory and economical application methods are developed for large reservoirs and lakes (1,000 surface acres and larger). The Southwest Water Evaporation Research Council is confident, however, that private industry will satisfactorily answer all of these questions and proceed with the development and marketing of suitable, approved processes and apparatus to meet this challenge.

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Use of Hexadecanol in Reservoir Evaporation Reduction

Bernard B. Berger

A paper presented on Oct. 15, 1957, at the Southwest Section Meeting, Oklahoma City, Okla., by Bernard B. Berger, Chief, Water Supply & Water Pollution Program, Robert A. Taft San. Eng. Center, USPHS, Cincinnati, Ohio.

THE US Public Health Service, like other agencies, wishes to contribute to the development of practical methods of water conservation. Among other reasons for this interest is the fact that public health pressures may be expected to increase as the adequacy of drinking water supplies decreases. Reports from Australia and East Africa, indicating the possibility of reducing evaporation loss by monomolecular films of hexadecanol, are, therefore, of keen interest to the USPHS. Conserving supplies of distilled-water quality is a particularly desirable objective.

The USPHS has expressed its desire to work with other federal agencies in determining the feasibility of this approach to conservation. Its contribution, it was stated (*1*), could cover the following aspects of film-producing materials: [1] human toxicity potential, [2] effect on fish, [3] effect on water treatment processes, [4] effect on recreational use of water, [5] resistance to biological attack. Studies of four * of these aspects were carried out at the USPHS Robert A. Taft Sanitary Engineering Center (SEC), Cincinnati, Ohio, on a laboratory scale.

* No tests were conducted to determine the effect of hexadecanol on water used for recreational purposes.

Human Toxicity Potential

In the last few years the SEC has received many requests for information concerning the toxicity of hexadecanol, the compound most frequently mentioned in connection with the production of monolayers. The following opinion is based on a literature search by the consultant in toxicology (*2*):

> Although there is no report of information known to us on the long-term ingestion studies of hexadecanol, this material, in one form or another, has been used in a domestic manner for many years without evidence of detrimental effects on the health of individuals. Indirect, but important, evidence indicating a considerable degree of safety in the use of the long-chain alcohols is indicated by the work of Treon of the Kettering Laboratory (*3*). Treon found that the oral toxicity of aliphatic straight-chain alcohols decreased sharply at the C-10 chain length. This implies that alcohols of longer chain length, because of lessened solubility and other characteristics, would have still further reduced toxicity. Supporting evidence is contained in the work of Stetten and Schoenheimer (*4*), who noted that hexadecanol is oxidized to the corresponding fatty acid, palmitic acid. This is a component of normal fat which, of course, is a common foodstuff.

Octadecanol, tetradecanol, and the unsaturated C-18 alcohols, often associated

with commercial hexadecanol, are normal metabolites of commonly ingested foodstuffs, and consequently would not be expected to present a health hazard upon ingestion in any reasonable amount.

Accordingly, in view of: [1] the lack of direct evidence of the hazard to health upon ingestion, [2] certain evidence favoring the view of its probable innocuousness, and [3] the improbability of ingestion of any but extremely trivial amounts as a result of the method of use, it does not seem reasonable to anticipate that any hazard to health would result from its use for the purpose, and under the conditions proposed, even though exposure were to be for the lifetime of the individual.

It is necessary to add that chemicals used with hexadecanol could conceivably produce a mixture with enhanced toxic properties. Therefore, preparations proposed for use should be independently reviewed for possible toxicity potential.

Effect on Fish

The SEC carried on a limited number of tests to determine the toxicity of hexadecanol for moderately sensitive fish. Fathead minnows were exposed for a period of 5 days to emulsified hexadecanol in concentrations of 1, 10, 100, and 500 ppm. All of the minnows survived, in spite of the fact that these concentrations were far in excess of the concentration that would actually be used in monolayer formation. The highest concentration of hexadecanol, 500 ppm, caused a visible film to form on the surface of the water. Because of the oxygen demand of hexadecanol in this concentration, dissolved-oxygen depletion was experienced, and the fish showed signs of stress, but this disappeared on aeration. It was noted that the fish actually consumed hexadecanol in the test container. The compound apparently passed through the fish, since fecal strings of what appeared to be hexadecanol were observed. It was concluded, therefore, that the material produced no direct toxic effect on fish. (Observations on the effect of the monolayer on fish food organisms were among the objectives of the 1956 study on Kids Lake [5].)

It was recognized that monolayers could conceivably produce adverse effects on fish by interference with gas transfer balances and by exerting a demand on the dissolved oxygen in the water. Under the proposed conditions of use of hexadecanol, however, it would be expected that such effects would be slight. Limited tests at the SEC showed no significant difference in reaeration rate between water with a hexadecanol monolayer and water with an untreated surface. Because of the very small concentrations of hexadecanol used, its BOD would be low, and even if completely satisfied, should not be significant.

A temperature rise resulting from evaporation reduction could conceivably produce adverse effects on sensitive fish during periods of normally high water temperature. Owing to the many factors influencing temperature gradients in bodies of water, these effects may best be studied in the field. The investigations of the SEC did not, therefore, include observations on the temperature rises to be associated with the presence of the monolayers.

Effect on Water Treatment Processes

Field use of hexadecanol monolayers was simulated in the SEC laboratory with paired 5-gal carboys, one of which contained hexadecanol pellets. Various substrates were used, with observation periods ranging from 20 to 48 days. Hexadecanol could not be detected by extraction, or by infrared

determination of the residual liquid. The sensitivity of these procedures would have permitted the detection of hexadecanol if present in a concentration greater than 5 ppb. These findings are not surprising, because of the low solubility of hexadecanol. Fatty acids and esters were present in small amounts following oxidation. These materials may represent an intermediate stage in the biological oxidation of hexadecanol to carbon dioxide, or they may have been present in the original substrate. Both fatty acids and esters are commonly found in surface water and should not be expected to cause difficulty in water treatment, unless they are present in abnormally large quantities.

Resistance to Biological Attack

The SEC made a careful study of the resistance of hexadecanol to biological attack (*6*). The specific question investigated was whether microorganisms naturally occurring in bodies of water metabolize hexadecanol. Three primary types of water were examined: [1] heavily contaminated water (2 per cent settled sewage in 98 per cent BOD dilution water), [2] moderately contaminated water (50 per cent Ohio River water and 50 per cent BOD dilution water), and [3] clean water taken from a spring-fed pond near San Antonio, Tex. In determining metabolic activity, the parameters used were rate of carbon dioxide production and loss of weight of hexadecanol. The study indicated that hexadecanol is readily consumed by microorganisms normally present in water.

1. In heavily contaminated water a rapid and accelerating rate of hexadecanol consumption was observed. The microorganisms present in this sample readily adapted themselves to metabolize this nutrient. No deterrent influence developed with exposure. A rate of consumption equivalent to 1.05 lb/acre per week during the first week of exposure increased to a rate of 3.3 lb/acre per week by the third week.

2. In moderately contaminated water an initial lag period was followed by a rapidly accelerated rate of hexadecanol consumption. This acceleration was followed by a sharp drop in metabolism of the compound. During the first week of exposure, a rate equivalent to 2.06 lb/acre per week was measured; by the third week, this rate had dropped to 0.79 lb/acre per week. Examination of the hexadecanol pellets showed them to be covered by a filamentous mat consisting of bacteria, fungi, and inorganic detritus. This mat appeared to restrict the spreading action of hexadecanol and, presumably, was partly responsible for the discontinuous film at the water surface. Carbon dioxide production from the system was decidedly reduced following formation of the mat. The addition of clean pellets to the water temporarily restored carbon dioxide production, but a similar decrease recurred as a result of biological growth on the new pellets.

3. In clean water the rate of hexadecanol consumption was relatively low, apparently owing to a deficiency of nitrogen, potassium, and phosphorus, which are required for microbial action. During the first week, a rate equivalent to 0.77 lb/acre per week of hexadecanol was noted; this decreased in the third week to 0.27 lb/acre per week. Here, too, an envelope of fungal filaments and inorganic debris formed on the pellet, preventing production of the hexadecanol film.

Conclusions

The results of these SEC tests refer to laboratory conditions and do not presume to represent actual descriptions of what will take place under field conditions. Final conclusions must necessarily be based on full field studies, but it is tentatively concluded that:

1. Hexadecanol poses no direct problem in fish toxicity. Adverse effects, if any, on fish food organisms may best be detected during field studies. Harmful effects on fish through depletion of dissolved oxygen should not be expected, because the BOD of hexadecanol in the concentration applied is not significant and the monolayer does not affect the rate of oxygen transfer.

2. Applying hexadecanol in the manner and concentrations proposed will produce no discernible effect on water treatment processes.

3. Microbiological attack could produce loss of hexadecanol and reduce film-spreading efficiency; it should, therefore, be considered in determining whether the use of hexadecanol will be economical.

The USPHS proposes to continue working with other agencies in developing practical methods of reducing evaporation by the use of a monomolecular film on the water surface. The SEC is particularly interested in extending its laboratory studies to full field experiments, in order to help determine the practical value of conserving water by this procedure.

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State Agency Programs for Monitoring Radioactivity in Illinois

Joint Discussion

A joint discussion presented on Mar. 28, 1958, at the Illinois Section Meeting, Chicago, Ill.

Department of Public Health—*Robert J. French*

A paper presented by Robert R. French, San. Engr., Bureau of Radiological Health, Div. of San. Eng., Illinois Dept. of Public Health, Springfield, Ill.

THE Illinois state health department has followed the increase in the use and production of radioactive materials by industry in the past 10 years with special interest in the unique wastes which might result and the potential disposal problems which they present. The department now administers the Illinois Radiation Installation Registration Law which resulted from a study of the effects of radiation on the Illinois population.

The radiological waste–producing activities already in existence in Illinois pointed up the urgency for obtaining background measurements of ground and surface water as well as of the atmosphere so that future pollution could be properly evaluated. It was readily apparent to the department that an effective monitoring program must necessarily include all waters within and bordering the state as well as representative sectors of the state's atmosphere.

Monitoring

The health department's water-monitoring program was started along the Illinois Waterway and has been in continuous operation since early 1956. This waterway receives or will receive radioactive materials from several sources. Argonne National Laboratory near Lemont, for instance, discharges treated radioactive wastes to a tributary of the Des Plaines River. It is gratifying to report, however, that Argonne periodically monitors the environment and that its data support health department findings that no substantial concentrations of radioactivity have resulted in surface waters or in the atmosphere within 25 mi of the installation.

A second activity consists of a series of experiments by Northwestern University designed to determine the fate of fission products in watercourses. This project is sponsored by the US Atomic Energy Commission and provides for the injection of certain radioactive materials which are representative of families of fission products. All injections are to be made into the Chicago Sanitary and Ship Canal. Only one injection has been made to date and it included sizeable quantities of scandium and tritium.

The third activity on the waterway is the Dresden Nuclear Power Station. The Illinois Sanitary Water Board has

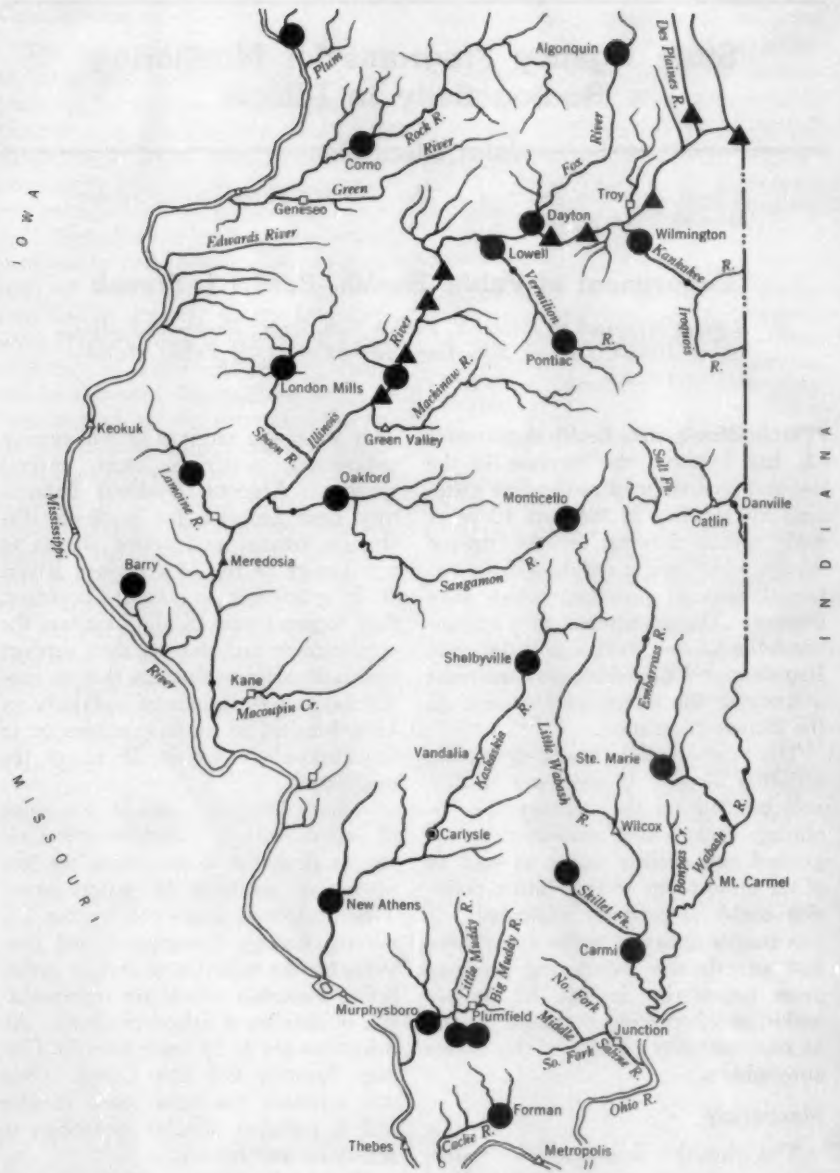

Fig. 1. Water Sampling Stations

Triangles represent stations used by the Illinois State Department of Public Health and circles indicate those used by the State Water Survey Division.

just issued its permit to Commonwealth Edison Co. permitting the disposal of Dresden's treated radioactive wastes to the Illinois River whenever concentrations do not exceed maximum permissible limits. The company is expected to limit gross alpha and beta-gamma concentrations to one-tenth of the maximum permissible limits, however.

The department's monitoring program on the Illinois Waterway has included analysis of 10-day composite water samples from nine locations between Lockport and Pekin (Fig. 1). Actually this was a cooperative venture with Chicago Sanitary District personnel collecting samples, the state health department laboratory in Chicago preparing the samples, and with Northwestern University doing the radiological counting work. No attempt was made to distinguish between suspended and dissolved solids. The total beta-gamma activity was determined by use of an end-window geiger counter. The final expression of results in terms of micromicrocuries per liter included an assumption that the overall efficiency of the counting equipment was 10 per cent. On this basis, the activity in these samples had ranged from 0 to 20 $\mu\mu$c/l except during the summer months of 1957 when activities as high as 208 $\mu\mu$c/l—believed to be due to fallout from the weapons-testing program—were noted.

Fig. 2. Proportional Counter Used in Study

Instrument was used to determine gross α and β activity in prepared specimens.

The Illinois River program also included periodic sampling of bottom deposits in the sanitary canal, the mouths of the Des Plaines, Kankakee, and DuPage rivers, the Illinois and Michigan Canal, and the Illinois River as far downstream as Marseilles. No significant amounts of activity have been found in these samples.

At the beginning of 1958, the lower four stations on the Illinois River were

eliminated to avoid duplication with the state water survey program and to permit expansion of the state health department's program. The water-monitoring program now includes monthly collection and analyses of waters from private wells surrounding the Dresden site. In addition, the first group of samples have been analyzed from private wells in a community where industrial liquid radioactive wastes were discharged to an open pit. None of these well samples has shown significant amounts of activity above background levels. All well samples are now being counted in department laboratories in Springfield and Chicago where proportional counting equipment is available. It is expected that the Illinois River work will be transferred to health department laboratories in the very near future.

Plans

Future plans include further expansion of the program for routine sampling of all major streams within and bordering the state. This work will, of course, be coordinated with the Illinois State Water Survey Division to avoid duplication of efforts for, in these early stages, data from either program are applicable to the other. Such data are essential to permit the Illinois Sanitary Water Board to continue to be of maximum service to both the general public and new industries.

Atmospheric Radioactivity

In addition to the water-monitoring program, the health department, for several years, has monitored radioactivity in the atmosphere at Springfield. The department has manned and operated, on a continuous basis, the only radiation surveillance network station in Illinois under the auspices of the USPHS to provide a record of the particulate beta activity in Springfield's atmosphere. During periods of weapons testing, increases 20–80 times the normal level have been noted for brief periods. In this program, preliminary estimates are made with survey equipment by personnel in Springfield and the more accurate counting on the sample is done by the USPHS in Washington. The department's atmospheric monitoring program will be expanded to include routine surveillance of the atmosphere at Dresden and other critical locations. In addition, the department has assisted the Argonne National Laboratory in establishing atmospheric monitoring stations at other points.

Need for Standardization

Early standardization of sample collection, preparation, and counting procedures is needed. It is understood that the USPHS already has taken steps in this direction.

Water Survey Division—*Laurel M. Henley, Richard L. Weatherford, and Thurston E. Larson*

A paper presented by Laurel M. Henley, Assoc. Chemist; Richard L. Weatherford, Asst. Chemist; and Thurston E. Larson, Head, Chemistry Sec., all of the Illinois State Water Survey Div., Urbana, Ill.

When the reality of atomic power plants and further widespread use of radioisotopes became strikingly evident a few years ago, the Illinois State Water Survey Division began consideration of the need for preliminary or

background data on the natural radioactivity of streams and ground water. No other agency in Illinois was actively participating in a planned statewide program for the collection of such fundamental data.

in its role of monitoring and prevention of pollution with radioactivity.

It appears reasonable that state-wide background data—to the extent that available funds permit prior to possible contamination—are essential in

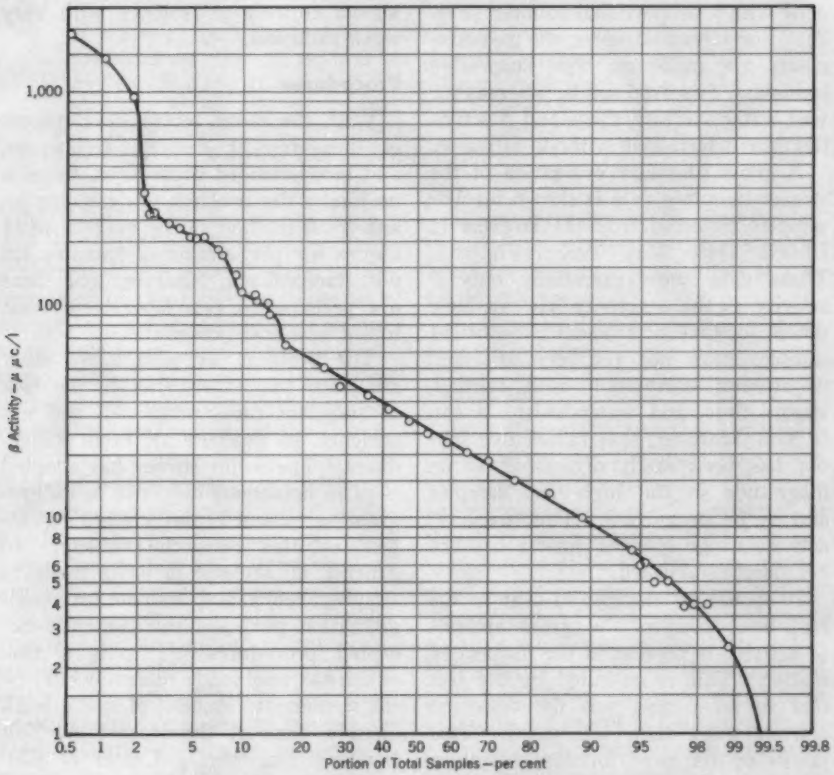

Fig. 3. Gross Summary Evaluation of Sampling Data

Data for 169 samples show essentially only β activity.

The function of the water survey, as a data collection and research agency in the field of water resources, is designed to be complementary to the function of the Illinois State Department of Public Health. Complete cooperation without duplication is being maintained with the health department evaluating data obtained subsequent to contamination from man-made sources.

Sampling Points

The current locations at which samples are collected once a month by the USGS for analysis by the water survey are indicated in Fig. 1. The sites

were selected on the basis of geographic distribution and availability of a gaging station for stream flow measurements. Also shown in Fig. 1 are a number of the stations sampled by the state health department.

Only gross α and β activity is measured with a proportional counter (Fig. 2). For stream samples, the measurements are made on both suspended solids and dissolved solids, whereas for well water samples, the α and β activities are determined without filtration.

A gross summary evaluation of the stream-sampling data is shown for 169 samples collected from 21 streams in Illinois since May 1957 (Fig. 3). These data show essentially only β activity as the α activity has not been noted to exceed 5 $\mu\mu$c/l. Sufficient samples have not yet been analyzed to attempt correlation with rainfall, stream flow, and watersheds. It can be said, however, that radioactive fallout has been easily detectable by its magnitude in the high-level samples and by its decay rate. The "natural" activity range of river waters has not yet been established.

It should be recognized that in the high-level samples the gross amount of activity is present in the suspended matter. This is indicated by the fact that in no sample was the dissolved activity more than 100 $\mu\mu$c/l. This points up the need for supplementary sampling of bottom sediment deposits. Since the half life of the major portion of fallout is relatively short, fallout in sediment can be recognized at least to a qualitative extent.

A few of the well water samples have shown significant radioactivity. These have been further tested at the Argonne National Laboratory where the activity has been found to be due almost entirely to isotopes with very weak radiation.

Procedures

With the more recent development of measurement devices, techniques, and recommended procedures, there is no longer the problem of designing an analytical method. The current techniques for preparation of samples are not standardized, however, and there are perhaps no two laboratories that follow identical procedures.

The problem, as with many other analytical procedures, lies in the lack of sufficient time, personnel, and experience to evaluate different procedures. The water survey has adopted —as an immediate objective in its program—a planned and continuing attack on this research problem. In general, an attempt is being made to simplify, refine, and evaluate for standardization purposes the currently accepted procedures. This is a task which has been made relatively easy by the tremendous amount of spade work already done at the Robert A. Taft Sanitary Engineering Center at Cincinnati, the US Atomic Energy Commission, various other federal agencies, and some equipment suppliers.

Developments in Artificial Ground Water Recharge

Task Group Report

A report of Task Group 2440 R—Artificial Ground Water Recharge, presented on Apr. 23, 1958, at the Annual Conference, Dallas, Tex., by John J. Baffa (Chairman), Cons. Engr., New York City. Other members of the task group were H. C. Barksdale, C. M. Bechert, M. L. Brashears, L. L. Hedgepeth, F. B. Laverty, A M Rawn, L. B. Losee, L. F. Warrick, and W. F. Welsch.

DURING 1957, questionnaires on artificial ground water recharge were sent to the ground water representatives of the USGS and the state sanitary engineers of each state as well as to state water control or conservation agencies where such were known to exist. A total of 92 replies was received with 47 states and the District of Columbia represented in the replies. No reply was received from Oklahoma.

In addition to analyzing the replies to the 1957 questionnaire, the task group has studied and summarized all available literature issued since its previous report (*1*) with particular reference to interim and recent developments in the field of artificial ground water recharge. For the first time, questionnaire data are presented on rates of artificial recharge currently in use in the United States.

Recent Developments

Outstanding recent developments in artificial recharge, as revealed by replies to the 1957 questionnaire in comparison with those of the 1955 questionnaire, are:

1. A sharp increase in the number of states which regulate the quality of waters disposed underground
2. An increase in the number of experimental projects and more speculation on the future possibilities of artificial recharge
3. More operating data available for existing projects.

Regulation

Forty-two states exercise some form of regulation over the quality of waters discharged to the ground. This number compares with the 22 indicated in the 1955 questionnaire. Details of administration of regulation were not requested but comments imply a variety of practices. For the most part, such controls are vested in the water pollution control agency of the state and administered by the state department of health. Control in California is on a regional basis and operates through water pollution control boards which are agencies established by the state legislature. In some states, the state health department can regulate only where the ground water is used for human consumption. In Nevada, the rules and regulations of the state health department are drawn to prevent contamination. Michigan reported that statutory control of ground water contamination was vested in its water re-

sources commission. In Texas, regulations are directed specifically at oil well–drilling operations. For Washington, both the division of water resources and the pollution control commission have authority to regulate recharge.

Arkansas

Arkansas, California, Illinois, New Mexico, New York, Texas, Utah, Washington, and Wisconsin are states with existing regional recharge projects. Arizona and Kentucky, which indicated the existence of regional projects in 1955, have replied to the contrary in the 1957 questionnaire.

Applied artificial recharge in the Grand Prairie region of Arkansas is in an experimental stage. The primary purpose of this work (*2–4*) is to conduct an investigation into the fundamental principles of applied recharge of ground water reservoirs in alluvial deposits. Irrigation pumping has dewatered the Quaternary sediments in this region and concentrated pumping from wells exceeds the natural recharge. The result is a critical water supply problem for the rice farmers and others living in the area. The dewatered condition of the Quaternary sediments provides a situation ideal for recharge experiments. Any favorable results arising from the investigations could be applied to the economic benefit of the region by providing, as a solution to the problem of storing surface waters, a ground water reservoir which supplements the ground water supply. Cooperating agencies in this work are the USGS, the US Corps of Engineers, and the University of Arkansas.

The Grand Prairie region project had its beginning in 1953. The character and distribution of geological materials composing and overlying the aquifer have been determined within a radius of 3 mi of the recharge site by means of 46 test holes. These test holes were cased and developed as observation points where water samples may be obtained and fluctuations in water levels recorded. Additional observation wells are located more than 3 mi from the recharge well and are intended to furnish data representative of the regional conditions unaffected by the recharge experiments.

The Stuttgart (Ark.) Chamber of Commerce Progress Report (*2*) states the objectives of the ground water recharge project to be:

1. To determine, by use of a vertical well, the hydraulic conditions set up in recharge
2. To determine the effect, if any, of chemical compatibility and bacterial contamination
3. To determine the amount, if any, of surface filtration and other treatment necessary for successful recharge using surface water
4. To make estimates of artificial recharge using results of the project as a basis for these determinations.

The first recharge test was made at 512 gpm to check the hydrologic constants calculated from aquifer tests. Data were also obtained on the effect of air entrainment and turbidity of the recharge water. The tests were described by Sniegocki and Guerin (*4,5*).

California

At the present time, the California Department of Water Resources is making an investigation of artificial recharge throughout the state and a published report is anticipated in the near future. A study in 1955 showed that 27 public and private agencies operated 78 artificial recharge projects and

planned 58 additional projects. The water that is spread in a major number of these projects goes into ground water basins which are common reservoirs for domestic, industrial, and irrigation supply. The injection of surface water to create a barrier to salt water intrusion is being continued in Southern California.

Illinois

The industrial area at Peoria, Ill., adjacent to the Illinois River is underlain by glacial till and alluvium deposits which serve as ground water reservoirs supplying the municipal and industrial needs of the region. The rate of pumpage from wells has exceeded natural recharge. Experimental studies of recharge using chlorinated river water were started in 1951 at the ½-acre Peoria recharge pit. Recent developments and data are described by Suter (*6–9*) and the 6-year operating record is reviewed. Recharge results are recorded at 14 wells surrounding the pit at distances of 90–3,700 ft. Nine industrial wells provide additional data on water levels, temperatures, and chemical composition. Recent developments include the observation that most of the recharge takes place through the sides of the pit rather than through the bottom. Temperature-depth data indicate that the rate of travel through the ground for warm water approximates the rate for cold water and that recharge water spreads on top of the ground water in the aquifer as far away as 4,000 ft.

Another recent development is the construction in 1956 of an additional ½-acre recharge pit adjacent to the first one, for the purpose of studying interference between the two. The results of 1956–57 winter operations indicate practically no interference between pits at a 3-mgd rate of application to the second pit. Chemical studies have included sampling to study relations between chemical contents of river water used for recharge and the water in the observation wells.

New York

Applied artificial recharge in New York State continues to be centered in Nassau and Suffolk counties where some 800 storm water recharge basins have been developed with successful performance. This program was compelled by the rapid growth of the region which resulted in increased ground water withdrawal with coincident increase of impervious developed areas. These, in turn, reduced natural recharge areas, for developed areas require construction to tide water of storm sewers, limiting available natural recharge. Research is continuing at the experimental storm water recharge basin at Garden City in cooperation with the USGS. Rates of infiltration have been determined under varying heads and inflow rates and under varying weather conditions. Correlations have been made with geological and hydrologic data, and evaporation studies have been conducted with a land pan and a floating pan. Test results to date show a range of seepage rates of 20–400 gpd/sq ft (*10*) at a basin-testing depth of 1 ft. These results emphasize the large effect of factors other than depth on the seepage capacity of such basins. The work of isolating and evaluating these factors is being continued.

Texas

It is reported that, in Texas, detention reservoirs were built in the cavernous sections of the Edwards limestone to increase surface runoff into

the limestone. The Edwards limestone area supplies irrigation, industry, and several municipalities—the largest of which is San Antonio. Results of recharge at El Paso were previously described (*1*). It is also reported that several municipalities may find it necessary to transport water 50–150 mi or more because of depletion of ground water, with the result that regional recharge operations may assume greater importance in the future.

Artificial recharge experiments were conducted at Amarillo's McDonald well field (*11*). Cooperating agencies are the Texas Board of Water Engineers, the USGS, and the city of Amarillo. The investigation was made to determine the hydraulic feasibility of storing water in natural underground reservoirs through the medium of injection wells. It is believed that the results of the investigations are applicable to many other regions in Texas. The need for the project arose from the fact that high-cost conventional reservoirs are necessary to meet the peak demands resulting from rapid growth of the city. Storage in the McDonald well field would make possible smaller pipe lines to new, distant well fields or surface sources and allow constant pump rates at these sources. In addition, there would be no evaporation losses from the underground reservoir and no storage costs, the only outlay being for the injection wells. Field studies included two pumping tests and a 4-month recharge test using two of the city's production wells and six observation wells drilled specifically for the tests. The results of the investigation showed that about 80 per cent of the recharge water injected during the winter months may be recovered by pumping during the remainder of the year.

Utah, Washington, Wisconsin

It is reported that a recharge experiment is being conducted in Utah by the Bureau of Reclamation in connection with the Weber Basin project. A regional recharge project is also contemplated in Washington in the vicinity of Walla Walla. It was expected that actual injection of recharge water would start in November 1957. An artificial recharge project is underway in Wisconsin to study the effectiveness and cost of recharging the sandstone formations in the Milwaukee area. This has been described by Muegge (*12*).

Legislation

Two states have been added to the list (*1*) of those that report legislation requiring the return to the ground of cooling water obtained from wells.

It is reported from Indiana that the ground water law—Chapter 29 of the acts of the 1957 Indiana assembly—gives the Indiana Department of Conservation the option to require that air-conditioning water be returned to the ground in restricted-use areas. In Iowa, under the new water law which is a permit control system, the water commissioner may require provision for the return of air-conditioning water before issuing a use permit.

In connection with the conservation of cooling water by return to the ground, legislation proposed by the Wisconsin Natural Resources Committee included the following provision:

> The board may require that all or part of the water withdrawn from such wells or an equivalent volume of water from some other source be returned to the aquifer or aquifers from which such well or wells withdraw water or to an alternate aquifer, with such purification, treat-

ment, and safeguards as are essential to prevent such recharge from deleteriously affecting the quality of underground waters.

Muegge (*12*) has commented that such a provision should be a part of any comprehensive water supply law.

In no state is cooling water obtained from a municipal supply required to be returned to the ground. In reply to the question as to whether it was desirable to have legislation requiring that cooling water be returned to the ground, respondents for fourteen states answered in the affirmative, 26 in the negative, and five did not answer. One answered "maybe" and one indicated that it was a local problem.

No state requires the recharge of storm water. Mississippi requires the recharge of salt water from oil fields.

Specific Projects

The aims of specific recharge projects in 1957 are reported as: recharge of municipal supplies, fifteen states; of industrial supplies, thirteen; of irrigation supplies, five; and regional supplies, nine states.

Sewage Effluents

Treated sewage or waste effluents are not used in any state for the specific purpose of recharge. In practically every state, however, such effluents are discharged to the ground and provide incidental recharge.

A 3-year study (*13*) of the technical feasibility and public health safety of injecting sewage effluents directly into underground aquifers was conducted in California by the Sanitary Engineering Research Laboratory under the sponsorship of the California Water Pollution Control Board. The experiment involved the recharge of a 5-ft thick confined aquifer located 95 ft underground. A mixture of settled raw sewage and water was used and it was found that bacterial pollutants traveled a maximum of 100 ft in the direction of normal ground water movement. Periodic injection of chlorine followed by shore redevelopment of the recharge well maintained its ability to receive injected water. Gravel packing of the recharge well was found to be necessary. The practical recharge rate was found to be about half the safe yield of the recharge well. The results show that direct recharge of ground waters with sewage effluents is a safe and hydraulically feasible method of ground water replenishment. Activated-sludge effluent from the high-rate activated-sludge plant at Hyperion, Calif., has been successfully used for recharge through an injection well after being passed through an intermittent spreading process on sand dune material 12 ft thick at rates of 1–2 cfs per wetted acre.

Induced Recharge

Induced recharge of water-bearing formations takes place when the natural rate of recharge from the surface is increased by an arrangement and location of the withdrawal wells which is such as to promote the natural recharge.

Induced recharge in Wisconsin is described by Muegge (*12*) who comments that water systems which bring about induced recharge can probably be found in most states. The best current installation of this kind in Wisconsin is described as consisting of two radial-collector wells at Manitowoc, both of which are located and constructed so as to induce recharge from Lake Michigan. Induced recharge at Canton, Ohio, has been described by Kuzmoun (*14*). It is also practiced at

Dayton, Ohio, and has been practiced for many years in the New England States and others in the East.

Reasons for Recharge

In answer to the 1957 questionnaire, the reasons for applied artificial recharge are given as: prevention of salt water intrusion, four states; general conservation of water, nine states; solution of specific water problems, eighteen states; maintenance of higher ground water levels, nine states; and improvement of the quality of ground water, three states. Twenty-four states indicated the existence of recharge projects of some type. Artificial recharge practice thus remains a matter of solving specific problems.

TABLE 1

Rates of Recharge Reported for 1957

State	Rate*	Type of Water
Recharge Basins		
California	0–10	percolated sewage effluent
Illinois	50–200	chlorinated river water
New Jersey	0.09–0.52	natural surface drainage
New York	1.5†	natural surface drainage
Washington	4.9	
Recharge Wells (Gravity Type)		
Arkansas	300–500	treated surface water
California	45–900	treated surface water
New Jersey	200	
New York	500‡	
Texas	500–1,000	
Recharge Wells (Pressure Injection Type)		
California	100–750	treated surface water
New York	500‡	
Indiana	400–600	
Texas	100–150§	

* All figures in gallons per minute per well except those for recharge basins which are in feet per day.
† Average.
‡ Maximum.
§ Information supplied by M. L. Brashears.

Rates of Recharge

Rates of recharge for surface spreading and well injection vary greatly in practice. Some of the factors affecting rates of artificial recharge include geology of the area, the permeability of the aquifer material, depth to ground water, quality of recharge water, and meteorologic conditions. Surface material characteristics will often control rates of recharge into free ground water bodies. Rates of recharge and character of recharge water (Table 1) are given to indicate the range of practice.

Conclusions

Data from the questionnaire circulated by Task Group 2440 R indicate a sharp increase in the number of states regulating underground disposal of water. A comparable increase in interest in artificial ground water recharge is reflected in the number of experimental projects reported. More operating data are now available and, in this connection, the committee wishes to call attention to the availability of an annotated bibliography on artificial recharge (*16*) prepared by David K. Todd.

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Removal of Hydrogen Sulfide in High Concentrations From Water

James E. Foxworthy and Harley K. Gray

A paper presented on Nov. 1, 1957, at the California Section Meeting, San Jose, Calif., by James E. Foxworthy, Research Assoc., Univ. of Southern California, Los Angeles, and Harley K. Gray, San. Engr., Southern California Water Co., Los Angeles, Calif.

THE Wadsworth Plant of the Southern California Water Company is located approximately 15 mi south of Los Angeles in what is know as the central basin of the Downey Plain. The water produced at this plant is used primarily for peak daily demand with the base supply purchased from the Metropolitan Water District of Southern California. The original source of water produced at this plant was a single well drilled in 1928. To meet the need for increased production, additional wells have been added throughout the years. The water produced has always contained relatively large amounts of dissolved gases—mainly hydrogen sulfide and methane.

To combat the problem presented by these gases, an aerator and detention tank were constructed soon after completion of the last well. With these facilities it was possible to provide treatment in the form of aeration, chlorination, and detention which proved adequate for a short time. Recently, however, the hydrogen sulfide content has risen to values as high as 20–30 ppm. It was found that the existing treatment facilities were inadequate, for a plant effluent of a milky blue color was nearly always produced. This color carried over into the distribution system and resulted in many consumer complaints. To determine an adequate and economical method of treating this condition a series of investigations and experiments was planned.

Theories explaining the presence of hydrogen sulfide in water and methods for its removal have been known to the public water supply industry for years. In low concentrations (< 4 ppm) hydrogen sulfide removal does not present too formidable a problem; in high concentrations, however, it can be removed only by methods that are involved and, usually, so expensive as to preclude the economical use of the water in large quantities.

It is well known that hydrogen sulfide is found in well supplies more often than in surface suppiies. According to Betz (*1*), hydrogen sulfide in well waters can be caused by nearness of the water to boulder clay areas or so-called "sour gas" oil fields. It is also known that hydrogen sulfide can be produced by chemical and anaerobic bacterial action in water-bearing strata. Wells (*2*) states that sulfates may be reduced to sulfides * by organic matter

* Except where it is desirable to indicate hydrogen sulfide in its gaseous state, the words sulfide and hydrogen sulfide are used here interchangeably to indicate total sulfides present.

under anaerobic conditions and that the metallic sulfide produced can, in turn, react with carbonic acid to form hydrogen sulfide. It is also possible to produce hydrogen sulfide by the action of various other anaerobic bacteria which break down organic material directly into its more elementary compounds. Wilson (*3*) has reported on the variation in chemical content that takes place in waters produced from aquifers known to contain large amounts of organic matter. He reports that water produced from this type of aquifer can contain high concentrations of hydrogen sulfide produced by the aforementioned bacterial activity.

The undesirable effects produced by water that contains excessive amounts of hydrogen sulfide are many. Water of this nature is extremely corrosive, attacking iron and steel to form "black water." The characteristic "rotten eggs" odor imparted to the atmosphere is a never ending source of consumer complaint. Many organisms flourish in an environment containing sulfides. Not only do these organisms reduce pipeline capacity but they also tend to "slough-off" at times into the system again to the dissatisfaction of the consumer. It can readily be seen that every effort should be extended to rid any domestic supply of this nuisance.

Methods of Removal

There are many methods that can be used for the removal of sulfides from water supplies. Sulfides are present in the form of metallic sulfides and hydrogen sulfide gas, and most removal methods employ some form of aeration. It has been found practically impossible to remove all of the sulfides by aeration alone (*4*); therefore, some form of oxidizing agent is usually relied upon to complete the removal by oxidizing the metallic sulfides to free elemental sulfur. In this more or less standard form of treatment the following chemical reactions can take place:

$$2S^{--} + 2O_2 \rightarrow SO_4^{--} + S^0 \quad \ldots\ldots (1)$$

$$Cl_2 + S^{--} \rightarrow 2\,Cl^- + S^0 \quad \ldots\ldots\ldots (2)$$

$$4\,Cl_2 + S^{--} + 4\,H_2O \rightarrow 8\,HCl + SO_4^{--} \quad \ldots (3)$$

The reaction shown in Eq 1 takes place during the aeration process. Hydrogen sulfide is released as a gas while the remaining metallic sulfides can react with the oxygen present to form free elemental sulfur. This elemental sulfur is colloidal in nature and, when present in sufficiently high concentrations, can give a milky blue cast to the water that must be removed by coagulation and filtration (*1*). In Eq 2, chlorine is used either alone or, following the aeration process, to oxidize sulfides to free sulfur. When Eq 1 and 2 are combined—as in the standard aeration-chlorination method of treatment—milky water is almost sure to appear when high concentrations of total sulfides are present. The ideal reaction would be that illustrated by Eq 2, in which no elemental sulfur whatsoever is produced. According to Black and Goodson (*5*), this reaction is difficult to control at normal pH values and free sulfur is the usual end product.

It has also been known for some time that the proportion of hydrogen sulfide present for removal is a direct function of the pH of the water. Pomeroy (*6*) suggests the following relationship between pH and percentage of total sulfides available as hydrogen sulfide. It can readily be seen that at reduced pH values a much higher

percentage of sulfide is available for removal by aeration.

pH	Sulfides Available as H_2S— *per cent*
5.0	98
5.4	95
5.8	89
6.2	76
6.6	56
7.0	33
7.4	17
7.8	7.3
8.2	3.1
8.6	1.2
9.0	0.5
9.4	0.2
9.8	0.079

From the results obtained with the existing treatment facilities it was indicated that aeration, chlorination, and detention as means of treatment were not enough to produce a clear plant effluent. At this time it was fairly certain that treatment in the form of coagulation and sand filtration could be restored to for the complete removal of sulfides. Derby (*7*) had reported earlier that excellent results had been obtained by this method in the removal of high concentrations of sulfides at Beverly Hills, Calif. It was felt, however, that a more economical method of treatment—from the plant cost standpoint—might be found. It was with this fact in mind that the following studies were begun.

Schiller (*8*) had conducted extensive experiments on water containing 6 ppm of hydrogen sulfide and high concentrations of methane gas. He conducted tests utilizing various methods of aeration, pH reduction, chlorination, chlorine dioxide treatment, filtration (through both iron and activated carbon), sodium hexametaphosphate treatment, and vacuum degasifying. Of these methods, only three produced water that was not milky in color. Using an iron filter to produce an insoluble sulfide removed all of the sulfides present, but enough iron was picked up in solution to cause another treatment problem. Filtration through activated carbon also removed all of the sulfides but the methane gas present in the water soon rendered the carbon useless. Vacuum degasifying together with pH reduction removed high percentages of sulfides. The effluent from the degasifier could be chlorinated or passed through a carbon filter to remove the remaining sulfides. Thus, milky water never resulted.

Pilot Plant

A pilot plant was set up at the Wadsworth plant in an effort to substantiate some of the above findings. Using a 50-gal oil drum and porous diffuser tubes, an aerator of the conventional forced-draft type was constructed. During the series of tests that followed, the results obtained earlier by Schiller (*8*) were verified completely. With conventional aeration milky water always resulted. Even with extremely high air-to-water flow ratios, the water always became cloudy. Maximum removal of sulfides by this method was 85 per cent—which compares with the experimental results obtained by Powell and von Lossberg (*4*) on a water of similar sulfide concentrations. Here, the effects of Eq 1 can be fully appreciated. During aeration, although much of the sulfide present is released as hydrogen sulfide gas, a considerable amount seems to be oxidized by the oxygen provided in this process. This oxidation can result only in the formation of elemental sulfur and milky water.

Aeration in combination with pH reduction was also tried. In an effort

to increase the hydrogen sulfide release rate, both mineral acid and carbon dioxide were used separately to reduce the pH of the water before aeration. The mineral acid was injected directly into the pilot plant influent by use of a small pump and mixing tank. The carbon dioxide was introduced through the diffuser tubes in the aerator. Various combinations of aeration and pH reduction were tried but the water produced was always milky in color. The best results obtained by this method were at a pH of 6.0 when 90 per cent of the total sulfides present were removed.

The vacuum degasification apparatus used consisted of an 11-ft section of 14-in. pipe set vertically on the ground and sealed at both ends. An inlet was provided at the top and an outlet near the bottom. The interior of the tank was filled with rock to break up the fall of water as it passed through the tank. A small vacuum pump was used to provide the desired vacuum. A variable-speed pump was used to provide different rates of flow through the tank. Provision was also made for pH reduction to facilitate hydrogen sulfide formation. This reduction was again accomplished by the addition of acid or carbon dioxide gas. A mixing tank just ahead of the vacuum tank provided detention and uniform pH reduction. A series of tests were conducted at various flow rates and pH values. The percentage of total sulfides which this apparatus was capable of removing was found to vary with pH, flow rate, and vacuum maintained on the tank. The greatest removals—as was to be expected—were obtained at the lower flow rates and pH values and with corresponding high vacuum. Removals of 98 per cent were obtained at a pH of 6.0, a flow rate of 1 gpm/sq ft, and a vacuum of 11 in. of mercury. The effluent from the vacuum tank was clear for the above conditions although aeration was necessary to raise the pH by driving off excess carbon dioxide in solution.

Results

In all of the tests conducted with this apparatus, clear water was produced when the effluent contained less than 1.0 ppm sulfides. On tests with higher flow rates at the same pH and vacuum, milky water was the end product. In an effort to increase the flow rates and get the same high removal, a method of recirculating the degasified effluent was devised. By passing the water through the degasifier twice, removals approaching 100 per cent were obtained with a pH of 6.0, a flow rate of 2 gpm/sq ft, and a vacuum of 10.5 in. Again the effluent was clear and needed only aeration for pH adjustment as additional treatment.

It appeared that the vacuum degasifier could be used as a means of reducing high concentration of hydrogen sulfide. The economics of this method of removal, however, was still to be investigated. During the tests it was found that addition of carbon dioxide was the most effective means of pH reduction. Therefore, any full-scale plant that was to be designed to utilize the method would have to be provided with some means of generating the gas. Extensive investigation of the problem showed that the burning of natural gas could be used as an economical method of carbon dioxide production. This burning to produce flue gas could take place in a separate installation and be either piped to the vacuum tank or produced directly in the tank itself

by the so-called submerged-combustion method recommended by some equipment manufacturers. In either method, it would be possible to introduce the gas at the bottom of the vacuum tank to provide a countercurrent flow of gas through the water. It was felt that this upflow of carbon dioxide would provide an agitation of the water which would increase the hydrogen sulfide release rate as well as provide the necessary pH reduction.

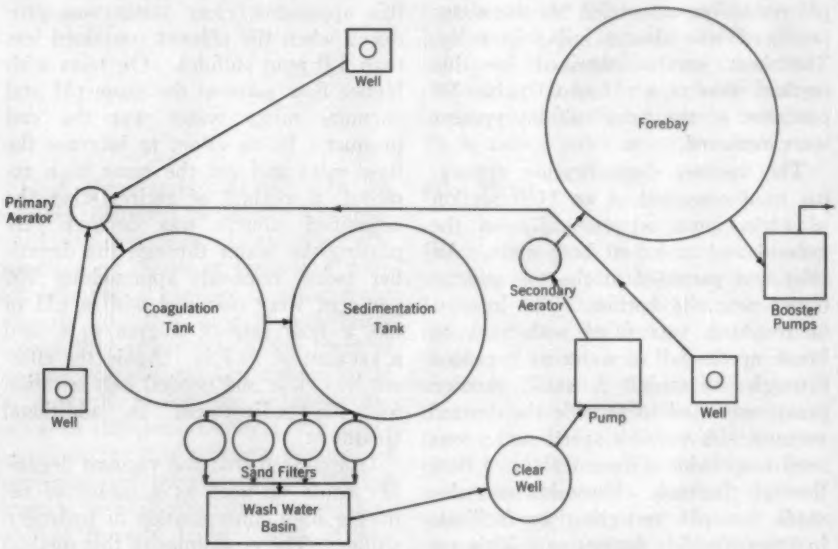

Fig. 1. Layout of Wadsworth Filtration Plant

Plant was completed in 1956 and has average flow of 1,200 gpm.

Obstacles

Although the preliminary pilot plant and economic studies looked favorable, it was found that the method of treatment could not be recommended for the following reasons:

1. The Los Angeles Air Pollution Control District requires that the maximum amount of sulfur as sulfur dioxide contained in a gas that is to be released into the atmosphere must not exceed 0.2 ppm. It was estimated that in order to stay within these limits, it would be necessary to produce 6,000 cfm of flue gas (600 cfm natural gas) with which to provide adequate dilution of the sulfides released to the atmosphere. At this rate of gas consumption the method appeared to be uneconomical.

2. The amount of heat produced by any submerged-combustion method of carbon dioxide production might be excessive. It was estimated that a water temperature increase of 30°F could be expected.

3. Further pilot plant studies would be required on a larger scale to determine the exact size and type of degasi-

fier and the other equipment that would be needed. The cost of this additional experimentation was found to be extremely high.

At this time, the economics of the problem pointed to coagulation and filtration as the best means of treatment. Further pilot plant studies indicated that a clear effluent, free of hydrogen sulfide, could be produced by aeration followed by chlorination, coagulation with ferric chloride, sedimentation, and subsequent sand filtration. The existing facilities, it was found, would fit into the design of this type of filtration plant and its construction was recommended.

Filtration Plant

The major portion of the filtration plant was completed by the summer of 1956. With an average flow of 1,200 gpm, the essential elements of the plant (Fig. 1) are as follows:

1. Primary aeration is provided in a conventional countercurrent type forced-draft aerator. Air is introduced at a rate of 200 cfm from a blower through porous diffuser tubes located near the bottom of the tank. Chlorine gas at the rate of 470 lb per day (35 ppm) and ferric chloride (in 40-per cent solution) at 120 lb per day (8.5 ppm) are added to the water directly below the diffuser tubes to provide adequate mixing.

2. Coagulation and sedimentation tanks follow the primary aerator. In the sedimentation tank, a detention time of 2.5 hr is provided at a surface loading rate of 760 gpd/sq ft of sedimentation tank area. The tank effluent passes over peripheral V-notch weirs to the rapid sand filters.

3. There are four 12.5-ft diameter circular filters using sand with a uniformity coefficient of 1.5 and an effective size of 0.50 mm. The designed filtration rate at average plant flow is 2.7 gpm/sq ft of filter bed area. Backwashing of the filters is accomplished by a centrifugal pump capable of producing a 30-in./min rate of vertical rise. The backwash water is discharged to a reclamation basin where it is settled. Most of the wash water is returned to the sedimentation tanks for recovery.

4. Secondary aeration is provided for pH adjustment just after sand filtration. This unit is of the same design as the primary aerator.

5. Postchlorination at the rate of 8 lb per day (0.5 ppm) follows the aeration process.

6. Storage facilities have recently been constructed which afford a combined storage capacity of 700,000 gal.

With these facilities it has been possible to produce a clear, potable water free of sulfides even though the influent water has, at times, contained 20–30 ppm total sulfides. A typical analysis of the finished water follows:

Item	Concentration ppm
Sodium	48
Calcium	36
Magnesium	12
Sulfate	17
Chloride	72
Carbonate	None
Bicarbonate	149
Sulfide	None
Total Hardness (as $CaCO_3$)	138

There have been no complaints of hydrogen suifide odor or bacterial growth from consumers since this plant has been put in operation.

Cost of Production

The Wadsworth Plant has been in operation for over a year and it has been possible to get a fair idea of the cost of treatment. Assuming an

average flow of 1,200 gpm and ferric chloride costs as $4.62 per hundredweight and chlorine as 5 cents per pound, the average cost of treatment is $7.10 per acre foot. The total cost of production—considering depreciation on treatment plant facilities, taxes, amortization, pumpage, and chemicals—is approximately $29.75 per acre-foot. This cost might seem high when compared to treated water that can be purchased for $22.50 per acre-foot (soon to be $26.50 per acre-foot). This water must be obtained, however, at a constant rate of flow and, therefore, large storage facilities must be provided to take care of peak demands. When the costs of the two waters are compared—with the costs of the necessary storage facilities considered—the treated well water compares favorably with that of the purchased water.

Conclusion

With successful treatment of well water containing 20–30 ppm hydrogen sulfide at a relatively reasonable cost should prove beneficial to others who may find themselves faced with a similar problem. Although it is true that a problem of this nature cannot be fully appreciated by water producers in areas where this type of sulfide water is never encountered, it should be pointed out that in regions such as Southern California where potable water is becoming increasingly difficult to locate and produce, problems of this sort will undoubtedly become more numerous as deeper wells are drilled. The investigation and solution of these problems as they arise are a challenge that must be met by the entire water supply industry.

Acknowledgment

The authors would like to express their appreciation to their many colleagues who have helped in the project discussed. In particular, the authors are deeply indebted to C. P. Harnish, president; and L. J. Alexander, R. M. Ebaugh, and W. S. Vrooman, of the Southern California Water Co. engineering department for their constant help and encouragement.

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The Relationship Between Depth of U-Tubes and the Aeration Process

Jacob Bruijn and Hendrik Tuinzaad

A contribution to the Journal by Jacob Bruijn, Engr., and Hendrik Tuinzaad, Engr., both of Munic. Dune Water Works, The Hague, Netherlands.

A FEW years ago a new aeration system had to be built at the Scheveningen pumping station of the Municipal Dune Water Works of The Hague, Netherlands. Research to determine the best type of system for this station was, therefore, carried out.

The purpose of aeration is to dissolve as much oxygen in the water as possible, and with the least possible energy. The velocity of dissolution is increased by a large area of contact between gas and liquid, and by a high grade of turbulence. The commonest aeration systems are applied by means of: [1] sprayers or cascades, [2] rotating brushes, [3] forcing compressed air into a column or a tube system which may or may not be packed with porous material, and [4] passing water through coke layers.

Aeration Experiments

The attention of the Municipal Dune Water Works was, however, attracted to an unpublished aeration experiment by the K.I.W.A.*

The apparatus for this experiment comprised a U-shaped tube, 3.2 in. diameter, mounted in a vertical position (Fig. 1). One stem of the U was a downdraft tube, 44 ft long; the other stem was about 9.5 ft shorter. The upper end of the downdraft tube was provided with an air injector which made the water flowing into the tube entrain air. The water and the air bubbles in the water at the lower end of the tube were, in accordance with its depth, under a pressure of 28.5 psi.

As the solubility of oxygen in water is practically linear with the pressure, the efficiency of this aeration system was greatly improved by the aforementioned high pressure. Table 1 shows the results of this experiment.

TABLE 1

Effect of Pressure on Aeration System Efficiency

Item	Case 1	Case 2	Case 3	Case 4
Level difference of U-tube stems—*ft*	7.2	9.5	9.5	9.5
Total flow—*1,000 gph*	16.0	16.0	5.3–6.6	4.0
CO_2 before aeration—*ppm*	160.0	161.0		160.0
CO_2 after aeration—*ppm*	128.0	136.0		133.0
O—per cent decrease in undersaturation	76.6	82.1	94.5	95.7

Another experiment with two concentric tubes was carried out by the Municipal Dune Water Works. Increase in oxygen content is expressed in "decrease in undersaturation" (*O*).

* Dutch research institute in the field of water purification and distribution.

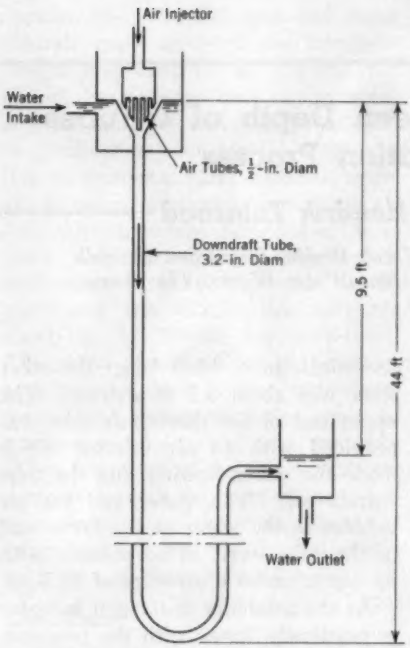

Fig. 1. Experimental U-Tube Aerator

This is an experimental structure, constructed by the K.I.W.A. (a Dutch research institute) to determine the efficiency of deep U-tube aeration.

This value is independent of the oxygen concentration before aeration, and permits comparison of the efficiency of several experiments.

$$O = \frac{C_2 - C_1}{C_s - C_1} \times 100$$

where C_1 equals oxygen concentration (ppm) before aeration, C_2 equals oxygen concentration (ppm) after aeration, and C_s equals saturation value of oxygen in water at the prevailing temperature and barometric pressure (11 ppm at 11°C and 760 mm Hg).

Aerator Construction

When enough data had been collected through experimental construction a plant aeration system was built with a total flow range of from 3.2 to 9.5 mgd. Figure 2 shows the aboveground section of this system; Fig. 3 shows the dimensions of the system. (The alphabet references in the following paragraphs are to Fig. 3.)

A 5-ft diameter concrete pipe was drilled into the ground to a depth of 50 ft. The lower end was closed. In this pipe (*B*) there was inserted a smaller steel tube (*A*), 23.5 in. diameter, suspended from the bottom of a concrete cistern (*D*). This cistern is connected to the water supply line and rests upon Pipe *B*. In the upper part of Tube *A* a wooden cone (*C*) was provided, leaving a ring-shaped space between the cone and the wall of Tube *A*. The position of the cone, when raised, is variable, thus enabling the total flow of the system to be increased while the pressure difference (*H*) between intake and outlet remains constant.

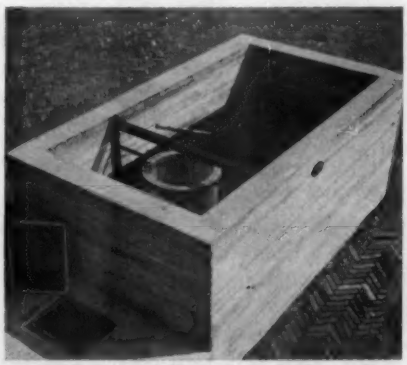

Fig. 2. Municipal Dune Water Works Aerator

This photograph shows the aboveground portion of the Municipal Dune Water Works U-Tube aerator.

In the opening between the wall of Tube *A* and the cone three crowns of plastic pipes were provided. Each crown contains 150 pipes, each having a diameter of 0.156 in. These pipes are in contact with the atmosphere and with different lengths of Tube *A* confirmed that the efficiency rises with the depth of the aerator. The results are given in Table 2 and in Fig. 4.

Figure 5 gives the characteristics of the deep U-tube aerator for a depth of

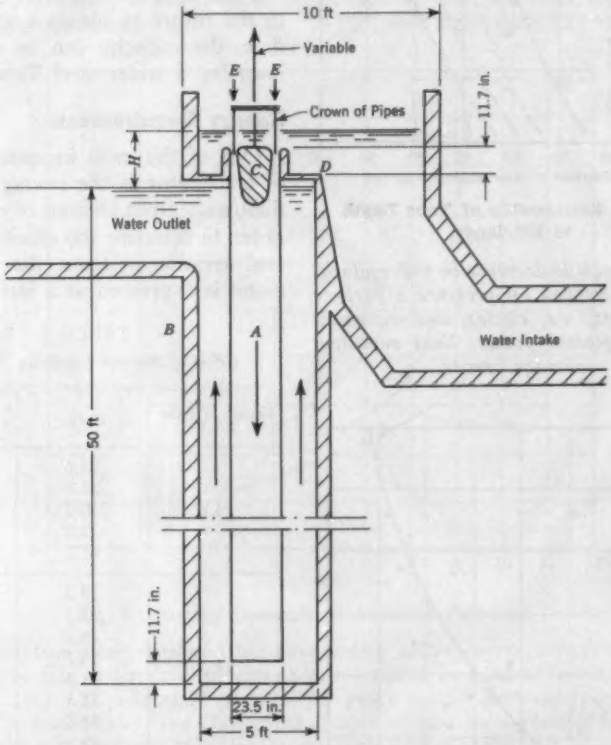

Fig. 3. Dimensions of Deep U-Tube Aerator

This diagram shows the dimensions of the different sections of the Municipal Dune Water Works aerator.

air is sucked through the pipes by the higher velocity of the water in the annular space.

Performance of Aerator

After completion of Pipe *B* and Cistern *D* the inner steel tube (*A*) was built in sections. Observations made 50.0 ft. It was further confirmed that a change in the total flow of the system obtained by changing the height of the cone does not affect the efficiency of the aerator. It is also of great importance that when the cone is in fixed position a large variability in total flow may be obtained at only a small pressure differ-

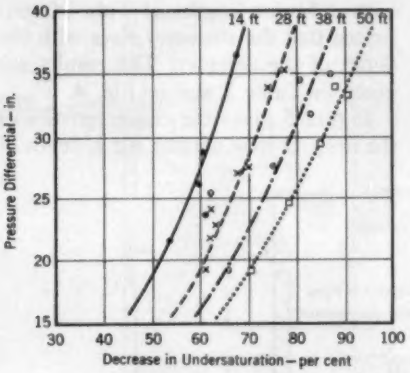

Fig. 4. Relationship of Tube Depth to Efficiency

Efficiency equals decrease in undersaturation (O) *divided by pressure difference* (H). *Dots, x's, circles, and diamonds represent plotted points; lines represent average curves.*

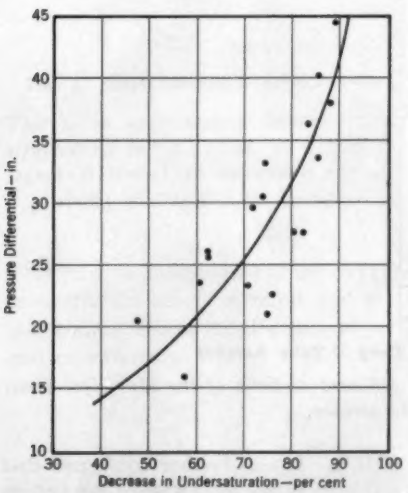

Fig. 5. Efficiency of 50-ft Deep Aerator

Efficiency equals decrease in undersaturation (O) *divided by pressure difference* (T). *Dots represent eighteen plotted points; solid line represents average curve.*

ence. For example, in a given position of the cone the pressure difference was 27.6 in. at a total flow of 3.2 mgd, and 39.4 in. at 6.4 mgd.

The diameter of the outer concrete Tube *B* is rather large in relation to the size of Tube *A*. If it is necessary in the future to obtain a greater total flow, the capacity can be doubled by inserting a wider steel Tube *A*.

Energy Requirements

One of the most important features of an aerator is the energy needed to dissolve a given amount of oxygen. In order to compare the efficiency of several aeration systems, the energy demand is expressed as a function of the

TABLE 2

Effect of Aerator Depth on Efficiency

Length of Tube *A*—*ft*	H—*in.*	O—*per cent*
14.8	25.6	53.3
	27.7	61.1
	30.3	59.6
	32.8	60.6
	41.7	67.5
28.2	23.2	61.1
	25.6	62.1
	26.8	63.2
	28.1	62.1
	31.1	67.8
	31.4	70.0
	38.0	74.0
	39.4	77.0
38.0	23.2	65.5
	29.5	62.0
	31.7	74.8
	35.8	82.5
	38.6	80.5
	39.0	87.0
50.0	23.4	60.8
	23.2	70.2
	28.7	78.2
	33.5	85.0
	37.4	90.8
	38.0	87.8

amount of oxygen added to a certain quantity of water at the same "decrease in undersaturation."

Figure 6 shows the energy requirements of three aeration systems: [1] rotating brush, [2] sprayer, and [3] deep tube. This figure is based on the most favorable conditions:

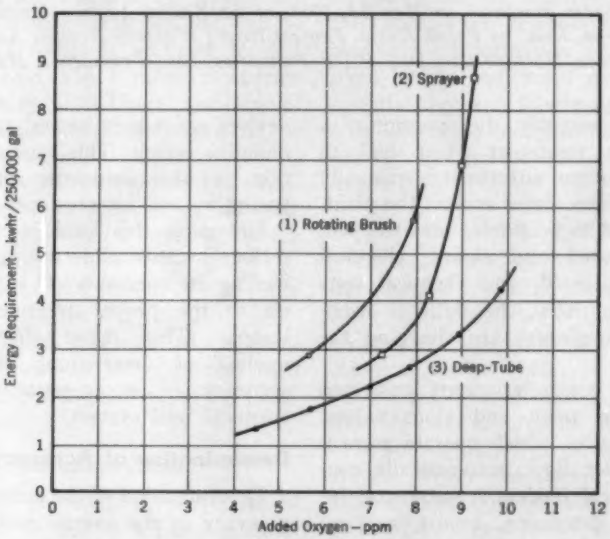

Fig. 6. Energy Demands of Aeration Systems

Oxygen absorption was calculated for oxygen-free water before aeration. Energy demand of deep-tube and sprayer aerators was calculated, in kilowatt-hours, upon total loss of head (H). *A yield of 75 per cent for pump and 90 per cent for motor was assumed. For total loss of head* (H) *of the sprayer aerator the difference between the level in intake pipe and the level in the filter was taken. For the rotating brush aerator the energy demand, in kilowatt-hours, of the motor was recorded.*

Diameter of shaft of brush—*in.*	6.2
Length of pens—*in.*	6.0
Part of brush below water level—*in.*	6.1
Rotation—*rpm*	110.0
Total flow of water—*mgd*	10.2

Advantages and Disadvantages

It is evident from Fig. 6 that the efficiency of the deep-tube aerator is much greater than that of rotating-brush or sprayer aerators. The efficiency improves accordingly as the point of saturation is reached. When 9 ppm of oxygen is added to the water the efficiency of the tube aerator is two to three times that of a sprayer or a brush.

In addition to its high efficiency, this aeration system has other advantages: [1] it needs little space, [2] little supervision is required, [3] no maintenance is necessary, and [4] the cost of construction is low.

A disadvantage is that no appreciable decrease in the carbonic acid content is obtained. The high pressure of the system is unfavorable for the elimination of gases. A calculation shows that very little CO_2 is eliminated. The data in Table 1 also demonstrate this.

Probable Accuracy in Proportional Pacing Systems

—Frank Russo—

A paper presented on Mar. 13, 1958, at the Kansas Section Meeting, Salina, Kan., by Frank Russo, Project Engr., Water & Sewage Sales, Omega Machine Co., Div. B-I-F Industries, Inc., Providence, R.I.

UNTIL recently, the operator of a water treatment plant had to make all control adjustments manually and at various places around the plant. Pumps had to be started and stopped, valves opened and closed, chemical dosages adjusted, and chemical tests performed. Now, the skills of scientists and engineers are changing the picture.

Remote controllers start and stop pumps and open and close valves. Pacing devices which operate according to water flow, automatically control chemical feeders. Automatic instruments determine, report, and record such information as pH and chlorine residual. Each of these advances in automatic operations allows the plant operator more time to devote to other duties and eliminates much work of routine nature.

Ease of operation is not the engineer's only intention when designing an automatic water treatment plant—economy is also important. The engineer wants to treat the water properly but as inexpensively as possible. For most uses, automatic controls tend to lower the cost of operation in water treatment. All automatic controllers have some inaccuracy intrinsic in their design, however, and, in one particular type of installation, several automatic devices operate in series, causing cumulative error. This type of installation is the automatic proportional pacing system for chemical feeding.

Errors in this kind of system are serious because underfeeding or overfeeding are uneconomical and an obstacle to the proper treatment of the water. This paper discusses the method of determining the overall accuracy of a proportional pacing chemical feed system.

Determination of Accuracy

Determination of the accuracy or inaccuracy of the overall pacing system is made from the accuracies of the component pieces of equipment. This usually must be done by the designing engineer. It is his responsibility to obtain a fair figure for the overall accuracy of the system. This may be determined easily from published information in manufacturers' bulletins if two points are clearly understood: [1] the concept of accuracy and range of equipment and [2] the statistical probability governing the operation of the equipment.

Often accuracy and range are stated separately and are not meant to be linked. The literature may state that the equipment has an accuracy of ± 0.5 per cent and a range of 20:1.

This does not mean that this particular piece of equipment will give an accuracy of ± 0.5 per cent over a range of 20:1. What it does mean is that over *some* given range, the accuracy could be within ± 0.5 per cent.

Accuracy should always be associated with some other condition. To say that a meter is accurate to ± 1 per cent means absolutely nothing, but to say that a meter is accurate to ± 1 per cent over a 5:1 range is specific and meaningful. There are several ways that accuracy statements can be properly presented. A few are:

1. Plus or minus x per cent of maximum rate, of capacity, or of full scale
2. Plus or minus x per cent over a definite range
3. Repeatability plus or minus x per cent of a set rate.

It is obvious that each of the accuracy statements is different and each must be fully understood to be properly applied.

Probable Maximum Error

After the accuracy of each piece of equipment needed in a plant installation has been properly determined, the problem of the accuracy of the overall proportional pacing system remains. Because the pacing system consists of several units operating in series, one method of determining overall accuracy would be to add arithmetically the maximum error of each component.

This method makes the assumption that all of the units would be operating at maximum error in the same direction. A statistical analysis of an appropriate operation indicates that this is not so. When independently operating units, each with its own error, are placed in series, the probability of one error compensating for another is high.

Therefore, the probable maximum error (PME) is equal to the square root of the sum of the squares of the errors of the individual pieces of equipment when they are set to give the desired final result.

Examples

The following examples illustrate this system for determining the total accuracy. Information normally supplied by the equipment manufacturers and the required flow range or range over which the equipment is to operate are given at the outset for each example.

Proportional Pacing System

In the system shown in Fig. 1 the hypothetical required flow range is 3–15 mgd. Accuracy of the flow meter (Venturi), the transmitter, and the chemical feeder (belt) is assumed to be the same for all—± 1 per cent of the rate over a range of 10:1.

In such a simple proportional pacing system, where the chemical feeder is to feed in proportion to the flow being metered by a flow meter, the range required falls well within the limits of the range for the individual units. It is safe to say, therefore, that the total accuracy of the complete system will be within the sum of the errors or ± 3 per cent over a 5:1 range.

Actually, however, the PME will be less than 3 per cent, for, by using the root-mean square formula, the PME at any rate is shown to equal $\pm\sqrt{(1)^2 + (1)^2 + (1)^2}$ or ± 1.732 per cent.

Pacing by Weigher

The required range in the arrangement in Fig. 2 is assumed to be 8:1. Accuracy for the parts of the system is taken to be ± 0.5 per cent of the

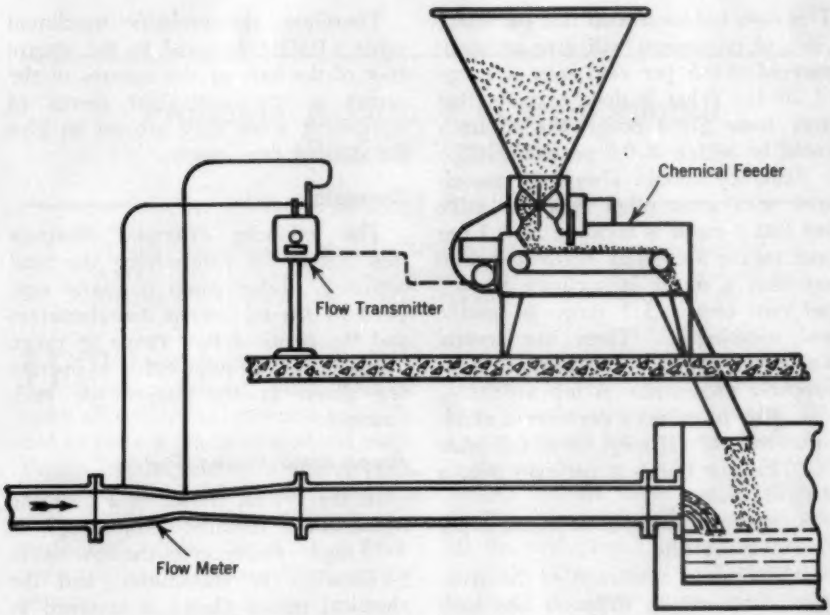

Fig. 1. Schematic Diagram of Proportional Pacing System

System is a simple one in which the chemical feeder feeds in proportion to flow metered by flow meter.

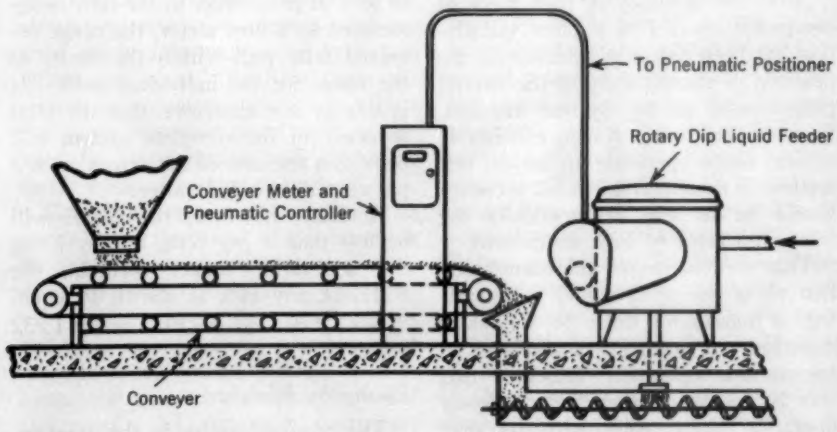

Fig. 2. Diagram of System Paced by Weigher

In this arrangement, error in weigher and pneumatic positioner will increase as the minimum setting is approached.

maximum rate for the weigher; ± 1.0 per cent over a 10:1 range for the pneumatic controller; the same for the chemical feeder; and ± 0.5 per cent of the maximum stroke for the pneumatic positioner.

This is another simple pacing system in which a chemical feeder is paced by a weigher so that the feed is in proportion to the weight of material handled by the weigher.

Here, again, the range required is within the range of the individual items. It is important, however, to note that the accuracy of the weigher and pneumatic positioner is ± 0.5 per cent of maximum rate and stroke. Hence, the error in these devices will increase as the minimum setting is approached. For this arrangement

$$\text{PME at 100 per cent} = \pm\sqrt{(0.5)^2 + (1)^2 + (1)^2 + (0.5)^2} = \pm 1.6 \text{ per cent}$$

and

$$\text{PME at 12.5 per cent} = \pm\sqrt{(4)^2 + (1)^2 + (1)^2 + (4)^2} = \pm 5.8 \text{ per cent}$$

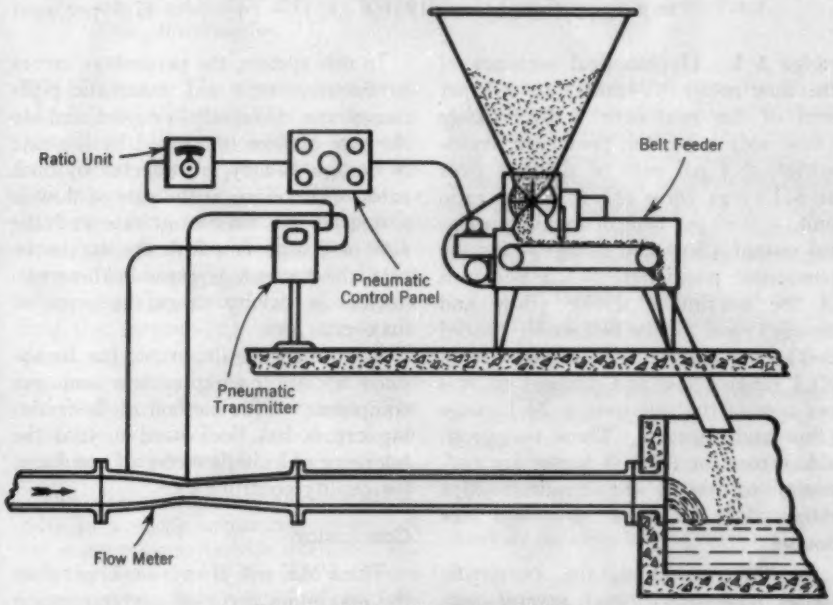

Fig. 3. Pneumatic Pacing System

In this relatively complicated system, a belt feeder is pneumatically paced in proportion to a metered flow.

It should be noted that the percentage errors in the weigher and pneumatic positioner are inversely proportional to the rate. As the rate is an eighth of maximum, the error is eight times as large.

Pneumatic Pacing

In Fig. 3, a belt feeder is pneumatically paced in proportion to a metered

flow. Required flow range is assumed to be 4:1 and the required dosage range 5:1. Hypothetical accuracy of the flow meter (Venturi) is ± 1 per cent of the rate over a 10:1 range (flow only); for the pneumatic transmitter, ± 1 per cent of the rate over an 8:1 range (flow only); for the ratio unit, ± 0.85 per cent of maximum signal output (flow and dosage); for the pneumatic positioner, ± 0.5 per cent of the maximum stroke (flow and dosage); and for the belt feeder (paced unit), ± 1 per cent of the rate over a 10:1 range (flow and dosage) or ± 4 per cent of the rate over a 20:1 range (flow and dosage). These two probable errors for the belt feeder are necessary to obtain the required 20:1 range—4:1 for flow and 5:1 for dosage.

In this operation, the pneumatic signal must pass through several components, each of which will impose its inaccuracy upon the signal before it reaches the feeder. It is important to note that probable errors shown for the ratio unit and the pneumatic positioner are those which occur at maximum conditions so that the error is increased as the minimum requirements of the system are approached.

To illustrate the application of the root-mean square formula here, the following computations of PME are given for different combinations of flow and dosage:

PME at 100 per cent flow and 100 per cent dosage

$$= \pm \sqrt{(1)^2 + (1)^2 + (0.85)^2 + (0.5)^2 + (1)^2} = \pm 1.99 \text{ per cent}$$

PME at 100 per cent flow and 20 per cent dosage

$$= \pm \sqrt{(1)^2 + (1)^2 + (4.25)^2 + (2.5)^2 + (1)^2} = \pm 5.2 \text{ per cent}$$

PME at 25 per cent flow and 20 per cent dosage

$$= \pm \sqrt{(1)^2 + (1)^2 + (17)^2 + (10)^2 + (4)^2} = \pm 17.5 \text{ per cent}$$

In this system, the percentage errors in the ratio unit and pneumatic positioner are inversely proportional to the rate of flow multiplied by the rate of dosage as they are affected by both rates. Therefore, if the rate of flow is a quarter the maximum rate and the rate of dosage is a fifth the maximum rate, the percentage error in these two devices is twenty times the error of maximum rate.

The procedure illustrated can be applied to any pacing system and any equipment. This method of determining errors has been used to find the tolerance of a single meter (*1*) and also for quality control (*2*).

Conclusion

The PME will always be larger than the maximum error of any component in the system but smaller than the arithmetic sum of all errors. If the individual errors of the units in the system are within the specified limits, the PME will be correct. Any deviation from specified limits will naturally affect the PME.

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2. EPSTEIN, B. Tolerances in Assemblies. *Am. Machinist,* 1:119 (1946).

Planning Water Supply Expansion for Anticipated Population Increase in Washington Metropolitan Area

Byron Bird

A paper presented on Oct. 31, 1957, at the Chesapeake Section Meeting, Washington, D.C., by Byron Bird, Chief Engr., US Army Engr. Dist., Washington, D.C.

THERE are 174 metropolitan areas in the United States today. A metropolitan area is defined as a city of at least 50,000 population plus its adjoining suburbs. All these areas have one thing in common—a tremendous growth with which come problems of increasing complexity. In the expansion, the central city spills over into the surrounding area, the traditional pattern of a city surrounded by separate communities disappears, and old boundaries are obliterated. The situation was well described in a recent newspaper article (*1*):

> Our city of tomorrow amounts physically to a single urban community. It has many community-wide interests. Politically, however, it has no unity—no identity even. It is a formless conglomerate of independent jurisdictions, each going its own way, often conflicting with neighboring jurisdictions in the process.

Officials of all metropolitan centers have been directing their efforts toward the proper solution of the many complex problems. Successful action has been taken in at least two centers—Dade County, Fla., and Toronto. In the words of the abovementioned article:

> The only real answer, the experts say, is a *firm plan* that will designate specific uses, and intensities of uses, for all vacant land in the region. The plan should be meshed closely with transportation and utility systems. It should establish definite relationships between the central city and its suburbs. To be effective, it must have the unified, intense support of governing bodies throughout the region.

Luther Gulick, president of the Institute of Public Administration has said (*2*):

> No longer can each small jurisdiction be permitted the privilege of dividing regional water resources; disposing of its own sewage and refuse; or maintaining subnormal standards of health, crime, or fire protection to a point which jeopardizes its defenseless neighbors.

Such conditions prevail in the national capita area, and their resolution is not for the experts alone, but is the concern of all those who live in the area.

Recent Action

Two recent occurrences have signaled the beginning of action toward solving the problems in the Washington metropolitan area. On May 2, 1957, a regional board of advisors was assembled to tackle the area problems. This group, under the leadership of the chairman of the board of commis-

sioners of the District of Columbia, is composed of the elected governing bodies of Montgomery and Prince Georges counties in Maryland; Arlington, Falls Church, Alexandria and Fairfax County in Virginia; representatives from both branches of the Virginia and Maryland legislatures; and a member of the Senate and House district committees. The second development was the creation, in August 1957, of a six-man special congressional committee to study area problems. Both groups are committed to a vigorous attack on all aspects of the problem, one of which—in the forefront at this time—is water supply for the region.

A most appropriate philosophy and guide for the water supply investigations is contained in a statement (*3*) made by Thomas A. Lane, former engineer commissioner of the District of Columbia, on the occasion of hearings on the Potomac River Basin in June 1957:

> It seems inevitable that the potential of the Riverbend dam will be a central element of your study. I am concerned because I recognize that the normal short-range periods upon which all of our planning information is forecast do not furnish an adequate basis for evaluating this project. We have population forecasts to 1980 and an occasional reference is made to the year 2000. No estimates are available for the year 2057 or later, yet these are the terms in which we should be thinking upon so basic a project.
>
> We face today the urbanization of the entire east coast from Boston to Washington, D.C. There is no reason to forecast any early termination of this trend. The implications are that the metropolitan area of the nation's capital will, in the next century, expand far beyond anything which present planners can foresee.

An adequate water supply is so vital to our civilization that when we pass beyond the needs of 1980 to those of 2057, there can be no doubt that the entire storage capacity of the Riverbend dam site will be needed. It is our responsibility today to foresee the need and to make provision for that sound ultimate development in the national capital area. It is most important that we develop in the first instance the full storage potential of the site. If we build a dam of lesser height, we shall establish an intermediate adjustment of the river regimen and promote great capital investment and development along the shores of the lake created. Thereafter our descendants, pressed for more water storage, could only realize the full potential of the site by destroying all of the investment of the bordering lake shores. This would indeed be a tragic dilemma to present to future generations.

If we develop the full potential of the site, the immediate use of the storage will be a matter of relatively little consequence. Whatever determination we make today can be adjusted by future generations to meet the needs of their time. We may allocate storage to flood control but our successors in 1980 may prefer another use for the storage. We may allocate a part of the storage for power development if it appears economical to so use water which is not now required for higher-priority needs. Another generation which has exploited the capabilities of atomic power will require this storage for municipal water supply or other essential purposes.

If the long-range plan for the national capital region will require the Riverbend dam, the time to build it is now. Our spreading population will soon be encroaching on the lands required for water storage above the dam site. The reservation of these lands should be made promptly to avoid later population displacement. In contrast, the up-river storage areas in the Potomac tributaries are not so threatened by urbanization, and the development of their storage ca-

pacities can safely be deferred. They would then be in reserve for future generations to develop as required.

The Washington District, under congressional authority to develop a comprehensive plan for the Potomac River basin, has reviewed available data in a preliminary approach to the problem. An attempt has been made to reduce the plan to its basic elements and, in the simplest and most understandable manner, to compress it into a compact picture extending over the next 150 years.

The basic water resources development problem in the Potomac River Basin is that of providing a plan for an assured water supply for the Washington metropolitan area. This, above all things, is essential to the life and growth of the area. The pattern of development of the river which results from the plan adopted will then dictate the measures to be taken to meet other needs—such as those of flood control, recreation, power, and associate matters of land use. With regard to the latter, loss of the best reservoir sites by unplanned and unregulated growth can mean disaster in the future.

Engineering Aspects

The engineering solution of the problem is essentially clear in its concept, however complex it may be in its detail and application. The necessary engineering elements are:

1. A population forecast
2. An estimate of domestic and industrial water supply demand by the projected population and estimates of water diversion for irrigation and dilution of waste discharges to the river
3. A determination of the capabilities of the river to furnish a dependable supply of water
4. An estimate of storage required to supply the water requirements during periods of deficiency of river flow
5. An inventory of reservoirs capable of meeting the storage requirements most efficiently and economically
6. Preparation of a plan.

Population Projection

A population projection is, at best, an educated guess. It can be both a guide and an objective and it is important that the projection used be the same for all agencies engaged in the investigation. Such a projection is being formulated by the Washington Board of Trade. According to estimates, the Washington metropolitan area population may be expected to be as shown in Table 1.

TABLE 1

Population Projections for the Washington Metropolitan Area

Year	Component			Total
	Maryland	Virginia	District of Columbia	
1965	890,000	625,000	895,000	2,410,000
1980	1,440,000	1,120,000	940,000	3,500,000
2000	2,150,000	1,650,000	1,000,000	4,800,000
2100	5,500,000	3,500,000	1,000,000	10,000,000

From the years 2000 to 2100, the population of the Washington area, it is estimated, will be approximately 1.5 per cent of the national total—now expected to be approximately 700,000,000 in the year 2100 (Fig. 1).

Determination of Demand

Tentative determinations of per capita water consumption in the area have been made and projected to the year 2100. Table 2 gives the amounts of annual average consumption obtained when these are applied to the populations anticipated. Figures may be pre-

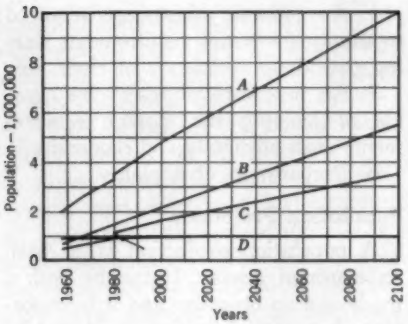

Fig. 1. Population Projections for Washington, D.C., Metropolitan Area

Curve A *is for the Washington metropolitan area;* B, *for Maryland;* C, *Virginia; and* D, *District of Columbia. Arrow indicates inclusion of Prince William County, Va., in metropolitan area.*

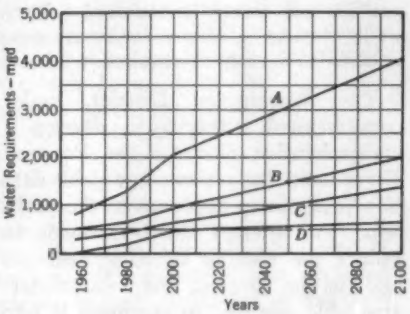

Fig. 2. Projected Water Demand for Washington Metropolitan Area

A *is curve of total demand;* B *represents pollution abatement demand;* C, *water supply demand; and* D, *irrigation requirements. Average flows (1930) for 30, 90, and 180 days are, respectively, 545, 590, and 740 mgd.*

sumed to include both domestic and industrial demands. They have been based on the combined usage figures currently applicable in the area. No heavy industrial demands are contemplated in the future.

The requirement for flow regulation for dilution of wastes after secondary treatment is still open for determination. For this discussion, however, a flow of 1,000 cfs or 650 mgd has been selected as the minimum desirable flow for conditions up to 1980. Beyond that date, the flow has been increased proportionately with water consumption. The rate is accordingly 950 mgd for the year 2000 and 2000 mgd for the year 2100.

Although diversions for irrigation will be made before the water reaches the Washington area—with consequent reductions in the dependable flows—for simplicity in calculations in this discussion, the irrigation demand will be added to the other Washington area demands. Although the studies of irrigation are far from finished, certain data have been assembled as to land classifications and their capabilities and water requirements for irrigation.

TABLE 2

Projected Annual Average Water Consumption for Washington Area

Year	Population	Consumption *gpcd*	Average Annual Demand *mgd*
1965	2,410,000	125	300
1980	3,500,000	128	450
2000	4,800,000	135	650
2100	10,000,000	139	1,390

TABLE 3

Projected Irrigation Demands for the Washington Area for the Months July–October

Year	Irrigation Demand *acre-ft*	Consumption—*mgd*	
		Average	Assumed
1980	127,000	324	216
2000	283,000	720	480
2100	384,000	980	650

Table 3 shows the average demands that could be expected during July, August, September, and October of the future years—assuming a rate of development equivalent to the now apparent national average. In later computations, however, to be conservative, only two-thirds of the assumed quantity was used.

The total combined demands are shown in Fig. 2, which also shows the basic dependable flows (as of 1930) without storage, for use in evaluating the capability of the river to meet the expected demand. The average flows for 30, 90, and 180 days are 545, 590, and 740 mgd. The monthly variation in water consumption in the District of Columbia system—averaged over the years 1931–56—is given in Fig. 3.

Using these ratios of monthly demands to the yearly average and combining them with the requirements for pollution dilution and irrigation, the monthly water demands for the years 1980, 2000, and 2100 were compiled. The mass curves are shown graphically in Fig. 4.

A determination of the storage requirements for the years 1980, 2000, and 2100 has been made by comparison of the mass curves of supply and demand in accordance with standard water supply engineering practice. This is also shown in Fig. 4. The net water supply storage requirements for

TABLE 4

Reservoir Data for the Washington Metropolitan Area Water Supply

Symbol	Reservoirs and Reservoir Sites	Storage Capacity *acre-ft*	Regulated Flow *mgd*	1957 Costs		
				Total—$	$/*acre-ft*	$/*mil gal**
A	Riverbend (235)	1,100,000	2,250	59,000,000	54	4.50
B	Riverbend (215)	540,000	835	36,000,000	70	7.00
C	Back Creek	120,000	135	8,000,000	68	10.00
D	Springfield	720,000	680	40,000,000	54	10.00
E	Patterson Creek	90,000	105	7,000,000	68	10.50
F	Conococheague	260,000	325	21,000,000	81	11.00
G	Cacapon	260,000	305	22,000,000	81	11.50
H	Millville	1,450,000	1,370	99,000,000	68	12.00
I	Royal Glen	330,000	415	31,000,000	90	12.50
J	Pinesburg	250,000	515	43,000,000	175	13.50
K	Brock's Gap	194,000	95	11,000,000	51	19.00
L	Karo	723,000	690	79,000,000	100	19.00
M	Rocky Marsh	40,000	85	15,000,000	351	29.00
N	Wills Creek	80,000	90	18,000,000	202	32.50
O	Orleans	270,000	550	110,000,000	405	33.00
P	Monocacy	250,000	205	51,000,000	202	41.00
Q	Harpers Ferry	240,000	485	134,000,000	567	45.50
	Savage River No. 2	20,000	26	5,400,000	275	34.00
	Stony River No. 3	27,000	33	7,300,000	300	36.50
	New Creek†	3,100		1,200,000	380	
	South River‡	8,713		900,000	103	

* Annual charges (fixed, operations, maintenance) divided by annual dependable flow in millions of gallons.
† Eleven structures.
‡ Sixteen structures.

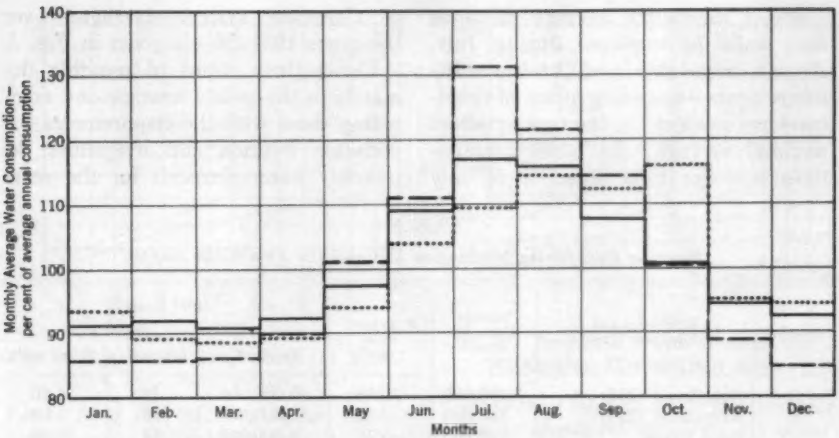

Fig. 3. Average Monthly Water Demand, District of Columbia

Solid line represents 1931–56 average; dashed line, 1953 average; and dotted line, 1930 average.

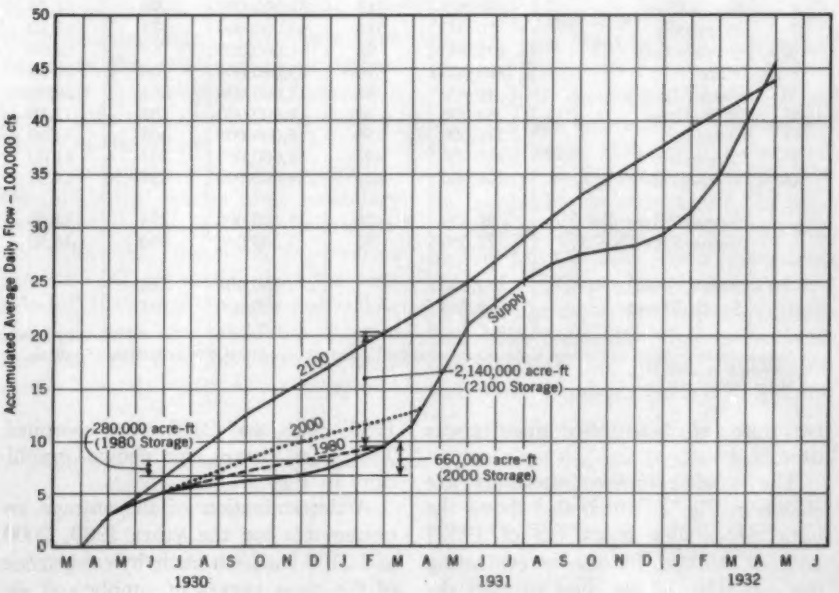

Fig. 4. Projected Monthly Demand for 1980, 2000, and 2100

Upper solid line is for demand for year 2100; lower represents supply based on 1930–32 period which had lowest flow on record. Years 1980 and 2000 are shown as dashed and dotted lines, respectively.

the Washington metropolitan area for the years 1980, 2000, and 2100 are 280,000 acre-ft, 660,000 acre-ft, and 2,140,000 acre-ft, respectively.

The curve of storage requirements, by years, to the year 2100 is shown on Fig. 5. It is of interest to note that for the 50-year period 1965–2015, storage requirements increase at a rate of approximately 20,000 acre-ft per year, which is equivalent to construction of one Savage River reservoir annually.

Reservoir Inventory

With these exceedingly important figures of Potomac River storage requirements for a period extending into the next century, it is now possible—with an inventory of available reservoir sites—to draw up various plans of progressive development for study from the standpoint of relative economy.

Table 4 lists known reservoir sites in the Potomac River Basin (Fig. 6) selected from more than a hundred which have been studied over the past 25 years and which are presently considere best for water supply storage purposes. These reservoirs range in size from one with more than 1,000,000-acre-ft capacity to small reservoirs, some of which have a capacity of less than 100 acre-ft. A few combinations covering the range of possibilities will be briefly discussed.

Schemes

Scheme 1, shown in Fig. 5, has been made up by selecting progressively those reservoirs which would meet the water supply requirements most economically. Riverbend (235) Reservoir, in first position, would satisfy the assumed demands until 2025. Back Creek Reservoir, of moderate size, appears next but would serve for only 10 years, when Springfield Reservoir could be brought into the picture to serve until after 2080. Using adjusted 1944 estimates, the total cost would be $136,000,000 and the cost of water, $13.50 per million gallons.

Scheme 1a (Fig. 5), places the Millville reservoir in the Springfield Reservoir position. This is done to illustrate the effect of major reservoir construction on cost. Also indicated is the fact that one major reservoir would serve until after the year 2000. The total cost would be $158,000,000 or $18 per million gallons of water.

Scheme 2 assumes a lower dam at the Riverbend reservoir and subsequent utilization of medium-size reservoirs. For approximately the same period of service, the following reservoirs are added in order of increasing water costs: Back Creek, Patterson Creek, Conococheague, Cacapon, Royal Glen, Brock's Gap, Wills Creek, and Monocacy. Here the total cost is $205,000,000 and the cost of water, $20.50 per million gallons.

Scheme 3 consists of all medium-size reservoirs with the omission of the Riverbend installation. The comparable cost is $337,000,000, with a unit cost of $26.50 per million gallons.

Scheme 4 is an assumption that the storage requirements could be furnished by small reservoirs. These reservoirs range in size from 75 acre-ft to 27,000 acre-ft and control 25–30 per cent of their respective watersheds. It may be a reasonable assumption that further studies of other watersheds in the basin will show similar capabilities but with greater difficulties in site location in areas of greater population densities. A tentative estimate of the total basin drainage area capable of development by such small reservoirs might give a figure of 25–30 per cent. Studies of the maximum practical degree of

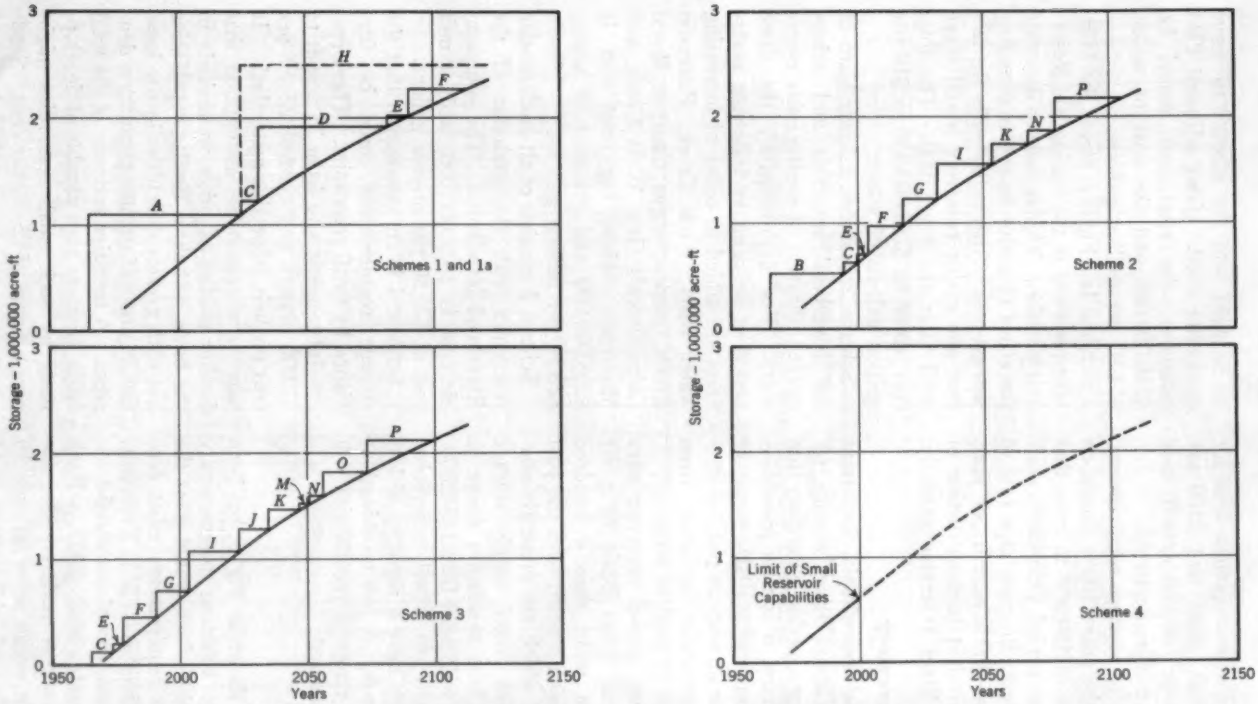

Fig. 5. Preliminary Schemes for Development of Potomac River to Year 2100

Letters correspond to reservoirs as shown in Table 4 and Fig. 6. Total capital cost and cost per million gallons, respectively, for Scheme 1 are $136,000,000 and $13.50; for Scheme 1a, $158,000,000 and $18; for Scheme 2, $205,000,000 and $20.50; for Scheme 3, $337,000,000 and $26.50. In Scheme 4, capital cost is not comparable and the cost per million gallons is $35–$37. All costs per million gallons are based on 1965–2100 demand curve. Curve in each scheme is of storage requirements.

flow regulation in the basin above Washington indicated that, with sufficient storage available to last through 3 years of drought, a flow of 9,000 cfs could be maintained at Washington. From the 25 per cent of the basin area controlled by small reservoirs, 2,000–2,500 cfs could be produced. To obtain the regulated flow by means of small reservoirs would require about 600,000 acre-ft of storage. From data thus far available, the water cost would be \$34–\$37 per million gallons. Complete development to meet the demand with this source alone would carry the load until about the year 2000. The alternate costs for the same period, using large reservoirs, would amount to \$9 per million gallons. It is thus apparent that development by small reservoirs is more costly unless such reservoirs can meet other specific local needs and secure local benefits sufficient to justify their selection over larger reservoirs. The overall plan should include consideration of the full range of reservoir capabilities.

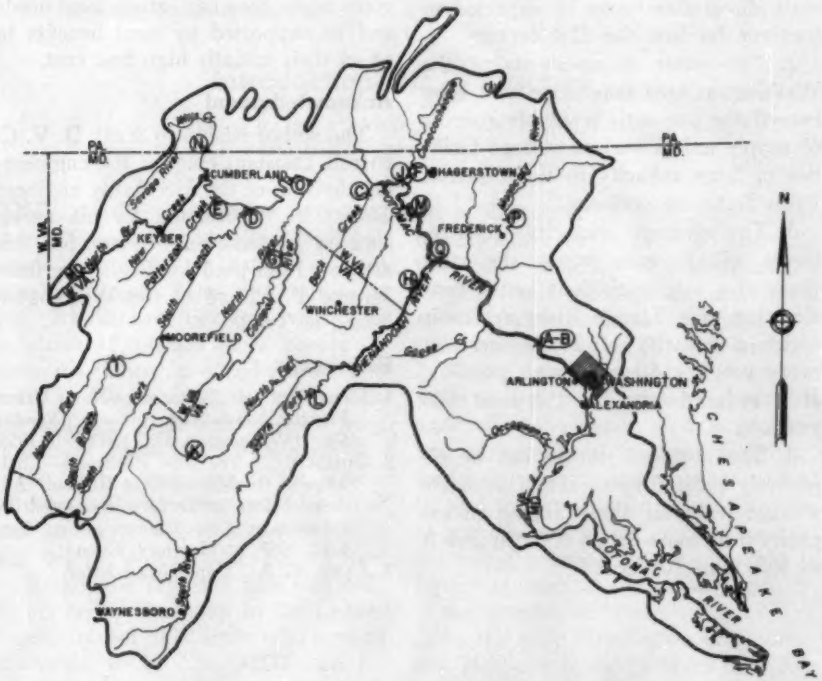

Fig. 6. Potomac River Basin Reservoir Sites

Circled letters refer to those sites listed in Table 4.

Conclusions

It must be emphasized that the foregoing analysis is based on the best information presently available. Much

work remains to be done. Costs of impoundment facilities are based on prices which are usually more than 10 years old and which have been brought up to date by the use of cost indexes. It may, however, be generally concluded at this time that:

1. The accelerated growth of the Washington metropolitan area—presently discernible—may be expected to continue far into the 21st century.

2. The water requirements of the Washington area population will soon exceed the presently available sources of supply unless surface storage facilities of large capacity in the Potomac River Basin are included.

3. The storage capacity requirements will increase during the early years at a rate equivalent to the construction of a Savage River reservoir (with a capacity of 20,000 acre-ft) every year for 50 years and, possibly, at a reduced rate for the next 100 years.

4. The required storage can be effectively secured by means of available storage reservoir sites ranging in capacity from more than 1,000,000 acre-ft to less than 100 acre-ft.

5. Greatest economy can be secured by utilization of units according to their capacity and availability, beginning with the largest.

6. The water supply demand cannot be adequately met by small reservoirs alone. It is becoming apparent that the final plan may consist of large reservoirs supplemented by small reservoirs where they can satisfy local needs and be supported by local benefits to offset their initially high first cost.

Acknowledgment

The author wishes to thank D. V. C. Birrell, assistant chief of the engineering division of the US Army engineer district in Washington for his assistance in preparation of data for this article. Data used for Fig. 1 are from Jerome P. Picard of the Washington Board of Trade.

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Utility Problems Resulting From Municipal Annexations

Panel Discussion

A panel discussion presented on Feb. 6, 1958, at the Indiana Section Meeting, Indianapolis, Ind.

Introduction—*M. P. Susanke*

A paper presented by M. P. Susanke, Chief Engr., Town Grading, Indiana Rating Bureau, Indianapolis, Ind.

THE world's population increases daily by more than 125,000 people, which is equal to populations of such cities as South Bend or Evansville, Ind. By this time next year there will be about 45,000,000 more people on earth than there are right now, and at the end of this century the population will have more than doubled from its present figure of 2.75 billion.

The United States population is now growing at the amazing rate of 1.7 per cent annually, which is nearly twice that before World War II. A few years ago, the reported rate was only 1.2 per cent. Estimates by the Census Bureau reveal this country's present population to be 170,790,000, an increase of about 14 per cent since the 1950 census, with a gain of more than 3,000,000 people.

On the local level, a recent count in Indianapolis shows nearly a 7 per cent gain, or an increase of 28,797, which is larger than the total population of the city of Bloomington, Ind., including the Indiana University registration. This increase is only within the city limits, and figures do not include suburban districts, which will be annexed not too far in the future. Perhaps other communities will never grow to that extent, but officials should consider whether their pumping stations, water supplies, and purification and distribution systems can cope with another 7–14 per cent increase. Recently, a judge ruled, when throwing out an annexation ordinance of a large city, that annexation of the area would retard its prosperity and progress. Also, he said that annexation would "impose obligations and duties" with respect to municipal services on the city that it could not meet at the present time or in the foreseeable future.

As the state distribution of gasoline and alcoholic beverage taxes to a city is based on population, it is generally said that the city should extend its boundaries to gain increased distribution of money and provide city services. Little thought or study is given to developing a definite and concrete program of annexation, so that the city can provide adequate municipal facilities to these areas. Such facilities should include extension of water mains, hydrants, valves, a secondary system of larger mains, adequate fire

and police protection, and sewers. The mere authority to do something does not necessarily imply that it automatically can be accomplished.

In the past, annexation has too often been motivated by spur-of-the-moment decisions. Today, however, there is real concern by all city officials to explore more deeply the many problems of annexation.

Fire Requirements

One of the problems facing water utilities and city officials is that of fire insurance classifications. The underwriters base their requirements regarding fire flow on total population, which must include that of newly annexed areas. As an illustration, if a city of 5,000 population decides to annex an area including 1,000 people, the requirement is based on the combined population, or a total of 6,000. The fire flow then would be increased from 2,250 gpm for 5,000 population to 2,500 gpm for the 6,000 population. Although the increase is only 250 gpm, which may be considered minor, there are other complications, such as the duration of the flow, which in this example is also increased from a 9-hr period to one of 10 hr. Although the increase in this example is relatively small, it does, however, have its effect, not only on main sizes for the new areas, but also on the present system. Furthermore, it affects storage capacity and the water supply as well.

All fire flows following annexation are on an upward trend, with the required amounts varying in proportion to the population increase. Naturally, it is assumed the annexed areas will have adequate distribution of hydrants, valves, and properly sized mains. If the area is not properly protected, a deferred fire insurance classification could be given to the newly annexed area, which would increase the deficiency against the city's total rating.

In determining the required fire flow, consideration is also given to structural conditions and congestion of buildings in a district. Residential districts are graded in a similar manner, except that when only about one-third the lots in a block are occupied by buildings of small area and low height, a flow of only 500 gpm may be required; if buildings are of a larger area or of greater height, a 1,000-gpm flow is required; where districts are more closely built or buildings consist of high-value residences, apartments, dormitories, or similar structures 1,500–3,000 gpm would be required. In densely built districts, with three-story and higher buildings, as much as 6,000 gpm may be required. These requirements are above the maximum day's domestic consumption demands.

Several recent annexations have shown that the fire flow requirements would be increased from 8 per cent to approximately 30 per cent, depending upon the city. One city will require 118 additional hydrants, another about 300, and still another about 900 new hydrants. All involve a very large expenditure of money, not only for the water department, but also for the fire department. Furthermore, if a city wishes to maintain its original fire insurance classification when large annexations are accomplished, recommendations are made for additional firemen, more fire stations or their relocation, plus additional fire apparatus and equipment, all of which may be included in the city budget but, nevertheless, are very expensive items. This further emphasizes the importance of sound economics and wise planning for annexations.

Planning for Expansion—*Ted Schulenberg*

A paper presented by Ted Schulenberg, Planning Engr., State Dept. of Commerce, Indianapolis, Ind.

The city planner is not usually responsible for the planning of water utility systems—this function being an integral operation of the company or department itself. The planner is, however, vitally concerned with the proper relation of utility systems to each other, to streets, and to land use districts which they serve. These relationships, of pressing concern to the planner, are equally important to the engineer responsible for the laying out of the water system. To find the best way to synchronize these planning operations is the problem at hand.

Water distribution systems, except in the smallest communities, are as old as the parent city itself. Mistakes or lack of foresight in the design of a system will be corrected when they become so serious that action can no longer be deferred. This reconstruction problem is comparable to the urban renewal phase of city planning.

Expansions, on the other hand, lend themselves to the principles of city planning just as logically as does the development of the city itself. In fact, utility expansions not based upon the comprehensive community plan can lead only to further confusion and waste of money and effort, which must be avoided.

City water systems are designed primarily to service present and future city areas, and they are poorly equipped to serve scattered developments in suburban areas. The expanding areas of a city are not usually within the city jurisdiction until annexations are accomplished. Therefore, it is necessary for those planning a city's utilities to have at hand the facts upon which they can intelligently base expansion plans.

Annexation Policy

A comprehensive plan, based upon projected population and industrial growth, is the first prerequisite of proper suburban growth. Many cities have adopted such a regulatory policy as a part of their comprehensive plans. After a careful study of the topography, street systems, existing developments, and future trends, residential, commercial, and industrial districts have been set aside for future city expansion. This is accomplished either by the use of a city's planning jurisdiction outside corporate limits or by cooperation with county or metropolitan planning agencies.

Water needs for future residential areas can be closely approximated by correlating population trends, areas available for development, and accessibility of other utilities. Future industrial water use in undeveloped areas cannot be so closely approximated, but planning can facilitate development by assuring convenient access to industrial areas for the unpredictable demands of the future. Industrial areas must be selected with consideration to easy water extensions at the time of need.

These are standards of planning which are accepted as necessary, but complications make it difficult to maintain a continuity of expansions. Annexation experiences uncover one of the principal complications.

To insure a continuity of city expansion, the annexation program must be laid out in advance and geared with the development of the city's fringe areas. Resistance to annexation in the past made it difficult—if not impossible—for many cities to plan sewage systems beyond their corporate limits. Unless the fringe areas had already been annexed, there was no assurance that such a move would be successful as a part of a service extension program. Disposal systems and water supply systems should be planned simultaneously and installed concurrently. The resistance to annexation is now diminishing in many areas where residential developments have precipitated demands for government services, which, in turn, tend to equalize tax costs on either side of corporate limits.

The Indiana annexation law is making it easier to justify city expansions in areas where utility extensions are planned. The incentive to plan utility extensions is greater, as the city has greater assurance of court support for annexations of areas that are needed for development of the city in the reasonably near future. With annexation criteria in the law, cities' expansion plans can be supported, and there is assurance that reasonable plans for expansion can be followed by annexation (and construction) when the time is ripe.

A number of cities have adopted annexation schedules as a part of their comprehensive plans. This approach is commendable. It notifies the residents of an area when they can expect to be assimiliated by the city, and it provides developers with a guide whereby they may synchronize their work with the capabilities for service expansions by the city and the utilities.

Subdivision Regulation

Subdivision ordinances are a tool that can be used to insure a continual development of the city. They may be enforced in the city fringe areas before the actual time of annexation. Subdivisions should be discouraged in areas remote from existing utility lines, but should be encouraged in areas contiguous to developed portions of the city. Practices of allowing developers to "leap-frog" undeveloped quarter-sections of land may be discouraged by subdivision standards. A maximum lot size (as well as a minimum) should be enforced in close-in developing areas. This can be done by subdivision regulations and by utility charges scaled to frontages of lots or distances to developments. The large 1–2-acre lots have a place in the development plans of many cities, but not in the path of high-density development.

Assessment practices are also in need of review. The owners of large vacant tracts, surrounded by developing areas, are often enjoying agricultural assessment rates, although the tracts are obviously being held for speculative purposes. Perhaps the term "speculative" is a harsh label to apply, but the history of such properties often justifies the term. A low assessment on such land encourages its owner to hold it for a good price at the expense of the city and its utilities. The public interest is not best served by long-range tax concessions, which are nothing more than a subsidy of private speculations.

Summary

It is evident that long-range planning principles must be a part of annexation policies. Such an approach charts the city's interests and needs, for the information of all component

interests—landowners, public works agencies, the utilities, the subdividers, and the home buyers. Every city in Indiana, except several fifth-class cities, now has an organized planning program. Annexation policy is one of their planning responsibilities.

If a city has not yet organized its fringe planning and annexation policies along the lines described in this article, such a program should be undertaken to minimize the frictions, misunderstandings, delays, and mistakes that will otherwise be inevitable.

Legal Aspects of Annexation—*Paul W. Philips*

A paper presented by Paul W. Philips, City Atty., Fort Wayne, Ind.

The problems of metropolitan areas in the United States, in this day and age, have been and continue to be the subject of much discussion and a great deal of writing. The movement of people from rural to urban areas is a major trend throughout the nation. All prospects indicate that it will continue unabated. With it have come many problems for the central city, the incorporated suburb, and the unincorporated fringe area.

Although a lot of good thinking has been brought to bear on the subject, many odd ideas have also been suggested and many mistakes made. Doubtless, errors will be made in the future also, but in the long run, the necessities of the various metropolitan area situations that exist or are developing will force solutions to the problems which they create. Meanwhile, a "head-in-the-sand" attitude means nothing but more trouble later on. In any event, the officers and employees whose duty it is to perform the functions of local government have never been busier than they were during the past 10 years, and the situation will probably get worse before it gets better. Any city official or employee in one of the areas presently affected by the trend toward urban extension who expects the volume of his expansion problems to lessen or level off is mistaken. This is a period of major and continuing urban growth and will be for an indefinite time to come.

A number of techniques have been suggested for handling the metropolitan area problem, and a number of different methods have been invoked in various parts of the country for its solution. One of the techniques is that of annexation by the central city. In Indiana, this is about the only method available. Perhaps in the future there will be some other techniques devised, and there may yet be some valuable ideas worked out under recent legislation. Meanwhile, the city, which is the only complete local governmental entity, appears to be the principal and best means through which to work out these problems in Indiana. Counties and townships are not corporate entities. The days of the township as a governmental unit are doubtless numbered. The structure of county government would have to be materially revised in order to be useful on this score. There are no special statutes in Indiana on the subject.

As indicated, annexation is the principal tool available to local government in Indiana with which to undertake to solve the metropolitan area problem. Fortunately, the state of In-

diana adopted in 1955 one of the best and most workable annexation statutes in the country. Used properly and with sufficient prior planning and care, this statute can be a workable solution to much of the metropolitan area problem in Indiana in most localities, with the exception of Indianapolis and the Lake County area. Those in cities other than in these areas are really quite fortunate, as they can avoid what has occurred in Marion and Lake counties and elsewhere in the country.

A rather impressive list of the various types or fields of municipal services which are involved in metropolitan areas could be made. This article, however, is concerned only with the problem of water supply and limited to a discussion of the position of municipally owned water utilities. Such utilities do not constitute "public utilities" under the Indiana Public Service Commission Act. Although in many respects a municipally owned utility is similar to a public utility, in many respects it is different. In any event, care should be taken not to confuse the two.

Statutory Authority

Before getting into the policy aspects of the position of a municipally owned water utility in connection with annexation, it might be well to take a brief look at some related legal matters. To begin with, it should be noted that municipally owned water utilities have statutory authority in Indiana to operate beyond the city limits of the owning city. As a matter of fact, there are six statutes pertaining to this subject. The principal one is the 1913 Public Service Commission Act, as amended in 1933 and 1935. By the 1933 amendment, municipally owned utilities were authorized to operate outside the limits of the owning city within a radius of 6 mi thereof. The 1935 amendment extended this to include the entire county in which the city is located. A 1915 act authorizes municipally owned utilities to operate anywhere outside its city limits, subject to public service commission consent. The 1927 Department of Water Works Act authorizes such departments to extend their lines to a distance of 5 mi beyond the city, in order to serve industry. In 1933, a second Department of Water Works Act authorized the creation of water districts to include a 5-mi radius beyond the city. A 1937 Act authorizes fifth-class cities and towns to extend their lines and operate to a distance of 10 mi from the central city or town, and a 1945 Act authorizes third-, fourth-, and fifth-class cities to extend a reasonable distance beyond their city limits, without commission consent, to serve war industries. The latter act has little if any present application, and the 1937 Act is limited in its application. Most officials, therefore, must look to the amended Public Service Commission Act for the source of extraterritorial authority. Probably, a radius of 6 mi plus the entire county is more than enough area for most of the cities to try to handle.

Another problem concerns the position of a municipally owned water utility where the city, by annexation, incorporates an area in which a public water utility is then operating. The Public Service Commission Act gives to the annexing city the absolute right to acquire such a utility, without Public Service Commission approval. But there is no requirement of a referendum on the acquisition in the situation where the annexing city already owns and operates its own water utility.

Three other statutes also pertain to the matter. The 1905 act permits such acquisition without commission approval but requires a public referendum. A 1921 act also permits such acquisition, with commission approval, but without public referendum unless required by the commission. In addition, a 1929 act permits such acquisition, but it applies only to an unencumbered water utility. Public service commission approval is required, but no referendum is necessary.

Conservancy Districts

Serious problems may arise in the future from the 1957 Conservancy Act. Under this act, conservancy districts are authorized to go into the water supply business, but nothing is said as to public service commission jurisdiction over water utility activities engaged in by conservancy districts. This is unfortunate, because if such districts do engage in this activity, they should be subject to the same controls as are imposed upon municipally owned and public water utilities. Perhaps if such districts build and operate water utilities, they might constitute a public utility under the Public Service Commission Act, but such a conclusion would be a doubtful one. It is important to note that the act prohibits a conservancy district from including a city or town within the district except with the consent of the mayor and common council or the town board thereof, unless the majority of the citizens petition to the contrary. There is no bar, however, against such a district going into the water works business in municipal fringe areas, whether or not the municipality is operating therein under its 6-mi jurisdiction. This could create serious problems and conflicts.

Perhaps in the future amendments may be enacted which will give cities some priority with reference to the extension of water service to their own fringe areas. The act does provide that an annexing city owning a water utility can, at the option of its mayor and city council, purchase the utility installations originally put in the annexed area by a conservancy district, but only if the governing board of the district and the supervising court agree. The statute requires the annexing city to pay for the installations it wishes to acquire at the conservancy district's cost. This might well be quite unrealistic.

Policy on Extensions

Much more important than any of the foregoing, however, is the policy matter of the position of a municipally owned water utility, as one of a number of important municipal services, in connection with annexation. Many persons have a tendency to consider the municipally owned water utility as some type of independent entity, which may go about its business within and without the city without regard to its position as one of the interrelated departments of that city. Many cities today find it difficult to interest suburban areas in annexation, because they have, without regard to protecting their own tactical positions, gone ahead with the extension of water service and sewer service to the suburban area. Although these are by no means the only important municipal services in which the people in a suburban area should be interested, they are usually the principal ones which such people consider. Consequently, if they already have these services, it is often, if not usually, difficult to sell annexation to them.

The various municipal services of a city, such as water, sewer, police protection, fire protection, street maintenance, garbage collection, and health protection, are all part of a single package and must in all events be kept together as such. They are mutually complementary and no one of them can stand on its own feet alone. This is a principle which cities must follow in the future, if they have not done so in the past. No area should be entitled to any municipal service unless it also contributes to the cost of providing the total municipal service program. The people residing in these areas use the city streets, parks, and airports. They often expect and get city police and fire protection in emergencies, simply because cities cannot humanly refuse them when needed. The extension of the services of a municipally owned water utility must, therefore, be part of the city's annexation program. Any city which extends such services on any other basis is simply giving away an important part of its bargaining position. When it does so, it often finds the suburban area, although economically dependent upon the central city, fighting against annexation, while continuing to use the city's services. Water service is of utmost importance on this score, because it is one of the two services the value of which these people most readily comprehend.

Of course, it is often difficult to correlate the extension of all of the various municipal services. Unfortunately, the theory and the practical necessities of the situation do not agree. There is a way, however, by which the city may protect itself in this situation with reference to water service. This is by including in all water line extension contracts and all water service contracts a provision under which, as part of the consideration for the service, the property owner or developer waives his right to oppose subsequent annexation by the owning city. This exact policy is contained in a 1955 statute pertaining to the extension of sewers in suburban areas, and there is no reason why the governing board of a water utility, under its rule-making power, cannot invoke the same condition for water extensions. In Fort Wayne, Ind., the city council has by resolution adopted the policy that, except for property adjoining existing suburban water lines at the time the resolution went into effect, no service can be extended unless under a contract containing an annexation waiver clause. This places the city in a position under which it can annex the area served when the city is in a position to make the other municipal services available. The option now lies with the city, where it should be.

City's Obligation

A city's protective attitude, however, must not be permitted to become a "dog-in-the-manger" attitude. If the city is to insist that suburban areas may not have municipal services except where the condition is immediate or ultimate annexation by the city and that suburban areas should not be permitted to incorporate independently and become competitive with the central city, then they must also be prepared and willing to annex these areas as rapidly as reasonably possible. A specific and intelligent annexation policy and program by the city is essential. Criteria must be established and financing arrangements prepared for. An affirmative, active approach from this

standpoint will usually handle the matter. Much planning is necessary, as is also a great deal of salesmanship. The extension of the services of the municipally owned water utility must be an integral part of this program. The people who operate the utility must see where they and their operation relate to the total annexation program of the city and must understand and assist in effectuating the policy upon which it is based.

Anticipated Expansion at Cumberland, Ind.

—J. B. Wilson—

A paper presented by J. B. Wilson, Cons. Engr., Indianapolis, Ind.

The town of Cumberland, Ind., was incorporated in 1951, and in 1957 it employed the author's firm of consulting engineers to develop a municipal water utility system for the town.

In preparing the original report, the engineers discovered that the town of Cumberland in its original incorporation had included a considerable area of undeveloped land.

To indicate the scope of the problem, it was estimated that it would be possible to serve slightly less than 300 customers for the presently platted town area, whereas upon future platting of the now vacant areas, there would be approximately 700 customers.

Translation of this situation into dollars shows that the initial cost of construction at present would be increased a full 100 per cent if the entire town area had to be served at this time. From the cost standpoint, all new construction jobs are running approximately $900 per connection, with minimum monthly rates of at least $3.50 for 2,000 gal and with annual hydrant rental in the $200–$300 category. If, to serve the entire town area, these figures had to be multiplied by two, there would be considerably more problems of engineering judgment and financing to be faced at the outset.

The initial recommendation of the engineers to the town officials was that it can, at the outset, serve only the presently built-up area. As Cumberland is located only 4 mi from the east city limits of Indianopolis, where now have been built or are now being built major manufacturing facilities, it is the author's opinion that expansion pressure will be evident at an early date in the town, because of proposed housing developments.

As it is historically true that new water systems do not have a chance to accumulate funds in the early years, there is only one answer to the future development—that all future water utility expansion will have to be paid for by the developer and be passed on to the property owner.

This community has the problem of expansion thrust upon a water system before it is even constructed. The mechanics of the planning and financing will have to be worked out later, and there will probably be a series of "annexation" problems typical of those faced by the expanding older communities.

—Expansion Results at Kokomo, Ind.—*Max A. Stearns*—

A paper presented by Max A. Stearns, Mgr., Kokomo Water Works Co., Kokomo, Ind.

There is one problem arising from annexation that confronts almost all local water utility managers. This problem definitely affects construction, operation, and maintenance.

The problem is that of the moral obligation due to the so-called monopoly of the water utility. This moral obligation is constantly being discussed by certain developers and government officials.

In any situation, obligations requiring expenditures of capital from which there is no fair return in revenues to the stockholders or the taxpayers are not sound, and they cease to be moral obligations. The so-called moral obligation, in which services benefit a few at the expenses of many, is an unfair obligation.

In Kokomo, Ind., annexation in the past has not been a serious problem. Today, however, community growth is on the increase, with the growth in areas near or adjacent to the city limits, causing annexation to become a serious problem.

Effects of Growth

Growth of Kokomo, due in part to annexation, has created changes in the source of water supply, construction work, operation, and maintenance. Long-range planning of construction in all phases of water utility operations is necessary in order to keep up with community growth.

The most noticeable effect of annexation is probably found in the expansion of distribution systems, because such expansion occurs more frequently than expansion of sources of supply and distribution pumping facilities.

From a water utility standpoint, the greatest objection to annexation is that it requires costly capital expenditures to the system, after which several years of time must elapse before there is a reasonable earning on the capital investment. At one time, the author made a test check to determine when an annexed area began to show returns on the investment. The test check revealed that 10 years elapsed before this area was a paying area. This result took into consideration the cost of mains, hydrants, services, and meters, as well as the revenue collected. If the revenue after depreciation, maintenance, operation, and taxes does not gross a 6 per cent return on invested costs, then the area is not considered to be a paying area. This 6 per cent return must also cover capital costs on sources of supply and pumping station facilities.

There are various methods of expanding distribution systems in annexed areas. At Kokomo, an agreement with the city requires that the utility install up to 500 ft of 6-in. or larger mains for each fire hydrant ordered in service by the Board of Works, in areas where there is no service at the time. If the Board of Works will not order fire hydrants installed, then the area falls under the state rules and regulations covering main installations.

It must be determined if an annexed area is subject to future expansion. This is essential in order that the mains installed be sufficient in size to allow for future expansion. Such planning eliminates duplication of mains in the future.

Insufficient Revenue

The greatest problem resulting from annexation is that of obtaining revenues sufficient to provide an adequate earning on capital costs. Because of modern planning agencies, both local and federal, this problem is serious. These agencies do not realize the burden they are placing on the consumers in the older sections of cities. Modern planning requires approximately twice the area per lot as the older sections of the city required, which in turn requires approximately twice the amount of mains to serve the same number of customers as in the older sections of a city. In other words, to serve newly annexed areas the utility must install twice the amount of mains required to serve older sections of the city. This results in a 50 per cent revenue from customers on the annexed area, as compared to revenue from the same number of customers in the older sections, per foot of main installed.

For example, in one annexed area at Kokomo, the utility was ordered to install one fire hydrant. The cost of installation, which included 500 ft of 6-in. main, was $1,675. The utility receives a hydrant rental fee of $50 per year. There are no customers. The $50 revenue is merely 3 per cent of the capital investment in the hydrant and mains, not even taking into consideration costs of depreciation, operation, maintenance, and taxes.

Present methods of determining revenues from annexed areas need to be revised, in order that customers in the older sections need not have to share in the expense of developing the newer areas.

Board of Health Concern—*George G. Fassnacht*

A paper presented by George G. Fassnacht, Chief, Water Supply Section, State Board of Health, Indianapolis, Ind.

There are two schools of thought on just what constitute problems in the water supply field that should come under the supervision of the state board of health. No one argues against the board's authority when the water is contaminated and causes illness. Few will argue authority when the water shows contamination in the absence of demonstrated illness. But some say that such things as pipe size, material and method of construction, pressures, rates, transfer of funds, and general business-like operation are no part of board of health concern. The philosophy in Indiana, however, takes issue with this latter group.

If the planners, designing engineers, municipal officials, and others concerned with the growth of the community would make it possible for the manager of the public water supply to furnish all the water his customers want when they want it, the state board of health problem would be relatively simple. It would be confined to clear-cut issues of water quality. The board would never get involved in the fringe areas of responsibility.

It is surprising how quickly the rugged individualist, who moved to the suburbs so he could live his own life, becomes gregarious when his well goes dry. The board of health may have an interest in his water supply even before he recognizes a problem. Too often, shallow wells located in the vicinity of sewers or septic tanks produce unsafe drinking water. Once the suburbanite agrees to, or is forced into, annexation, he is ready to demand all the services available from the incorporated community.

If the incorporation has not included plans to serve the new boarder at the table, trouble lies ahead. To carry the analogy further, the platter of pork chops that started down past the star boarders (the old customers) may be picked clean before it gets to the new man at the foot of the table. If he is to eat pork chops, one of two things must happen: either the landlady must start a second platter at the foot of the table, or she must start a bigger platter with more pork chops at the head. If she hasn't planned ahead enough to cook extra pork chops, of course, no number or size of platters will help the new boarder.

In terms of water, this means that a source of water must be developed to serve the suburban area, or new and bigger mains must be extended from the original source into the new area. The new source may be a well, or a booster pump if the existing system will support such a design, or an elevated tank.

Extension of Services

There is now a trend in the Federal Housing Administration, and also among those who control the money, to require community water systems for new subdivisions. The state board of health has been asking for facilities of public water supply caliber in the larger subdivisions for several years. If the subdivider can get city water, fine; but if not, he has to supply his own system.

Recently, two subdividers have asked privately owned public water supplies to serve their properties. A third is negotiating with a municipal supply to do the same. Two of the subdividers will put in their own wells and distribution systems. One of the private water companies, which distributes surface water, is drilling a well to serve its subdivision. All three properties will be taken into the municipal systems when the towns grow out to the properties.

Effective main extensions are neither haphazard nor jerry-built. All too frequently, main extensions are developed a block at a time to meet the immediate needs. No thought is given to what will be required next year. A few hundred feet of 3-in. main are stubbed on the end of a 4-in. dead end. Then, some blocks of 2-in. pipe are added to the 3-in. main. A few new homes built along the highway need water, so the owners tap on with a 1-in. line. This type of building leads to trouble. Another poor approach is that taken by one town in Indiana, in which the town board put up one-half the cost of drilling street corner hand-pumped wells to meet water demands in the fringe areas of the community, instead of running pressure service from the public supply.

Still, that is no worse than the proposal submitted by one designer for a church camp grounds. His plans showed ½ mi of 4-in. main extension and 2-in. grid to serve a normal camp load of 600 people, with 2,000–2,500 on a peak day. Fire hydrants, which

he was told to remove, were indicated on the end of the 4-in. line. What he did not show was that his 4-in. main connected to a 3-in. dead end at the edge of town.

The board of health wants city water extended wherever it is financially feasible to do so, but it must be extended in such a manner that the quality will remain safe and the supply adequate.

Examples

In spite of good standards for construction, which call for separated water and sewer lines in individual trenches, there are places where the two are close together, sometimes as parallel lines and sometimes in necessary proximity where service lines or house sewers cross the mains or sewers in the street. Both systems can, and usually do, leak to some degree. In house and industrial plumbing there are often potential interconnections where backsiphonage can occur. What happens, under these conditions, when pressures are so low that householders install their own booster pumps to get water in usable quantities? What happens in a system barely adequate for domestic use when the volunteer firemen wheel a pumper up to a hydrant, slap on a suction line, and pull a vacuum? Is this a problem for the fire department, or the board of health, or both?

In 1947, a county seat town undertook modernization of its public water supply. Water was pumped directly to the distribution system from wells. There was no storage, elevated or otherwise. The board felt that elevated storage was indicated at this locality, both on general principles and in view of the existing distribution system and use demands. The engineer was influenced by the city officials who refused to consider a rate increase, even though the existing one had been in use without change for 50 years. The bond issue was tailored, therefore, to existing revenues and the design was cut to meet the bond issue.

In 1955, less than 10 years later, a new project was underway to correct the deficiencies left by the earlier construction and created by community growth. Pressures had become erratic and fire flows insufficient. During the dry years of 1953–54 the water supply for several thousand people had periods of actual failure. Incidentally, construction costs rose 50–60 per cent between 1947 and 1955, and the original 2¼ per cent bond issue was refinanced with bonds costing 4 per cent. Was the original project strictly a fiscal problem for the town officials, or did it have health implications? Poor management is a health problem when suburban extensions are impossible because the utility is virtually bankrupt.

Summary

Planning for extensions is necessary, and it is a concern of the state board of health. The board expects to cooperate with communities, under authority of state law if required, and with their public water supplies, in order that as many citizens as possible may have safe water—at least all they need, when they need it.

Establishing Fair Value in Water Rate Determination

Hugh H. Hunter

A paper presented on Oct. 31, 1957, at the Chesapeake Section Meeting, Washington, D.C., by Hugh H. Hunter, Chief Engr., Maryland Public Service Com., Baltimore, Md.

IN discussing water rate cases, the agencies which have jurisdiction over water rates must be considered. These agencies—utility regulatory commissions—may be called public service commissions, public utilities commissions, or any of a variety of names, depending on the political subdivision.

Among the more important duties of the commissions is the regulation of rates and service. In the performance of their duties, the commissions are acting under the powers delegated to them by their respective state legislatures.

It is the legal duty of the state legislatures to fix rates and establish standards of service for industries which have been defined as public service companies or public utilities. These industries are usually natural monopolies, for which the ordinary market place regulation of competition will not work. The legislatures actually fixed rates for utilities in the early days of regulation, but experience soon demonstrated the need for a separate body which could function on a full-time basis and which could have a staff of trained persons available to work on the special problems arising.

The state legislatures began to delegate their powers of ratemaking to utility regulatory commissions about the beginning of the twentieth century. The practice spread rapidly until at the present time all of the 48 states, the District of Columbia, and the territories of Hawaii and Puerto Rico have established commissions to regulate public utilities. In addition, regulation at the federal level is carried on by the Interstate Commerce Commission, the Federal Power Commission, the Federal Communications Commission, and the Securities and Exchange Commission.

When the commissions were formed, the legislatures specifically defined the duties and responsibilities of the new bodies; among the most important duties was the regulation of rates and service. In the section of the law dealing with rates the legislature usually laid down some broad principles to guide the commission along its regulatory path.

Meaning of 'Fair Value'

Two of the important guideposts concern the establishment of the value of the utility's property for ratemaking purposes and the determination of a rate of return to be allowed on the established value. The exact language of the law varies from one state to another, but the following section on valuation from the Maryland law is probably representative of a number of states:

The commission may investigate and ascertain at any time the fair value of the property of any public service company used and useful in rendering service to the public.

On the subject of rates the law reads:

"Just and reasonable rates" means rates which are not in violation of any of the provisions of this article and which will result in an operating income to the public service company, yielding, after reasonable deduction for depreciation and other necessary and proper expenses and reserves, a reasonable return upon the fair value of the company's property used and useful in rendering service to the public.

In both of the quoted passages the words "fair value" are used. These same words are used in the commission laws of many states and this has led to the designation of these states among regulatory personnel as "fair-value states."

With an abstract subject such as "fair value" to consider, it might be assumed that the courts' decisions and interpretations would be both voluminous and elaborate—and such is the case. The determination of fair value has been described as "the most speculative undertaking" imposed on the courts "in the entire history of English jurisprudence."

The famous case of *Smyth* v. *Ames* (*1*) came before the Supreme Court of the United States following the depression of 1894. Among the many issues in the case were the unreliability of the public utility's property records, the suspicion that book values had been inflated, and the belief that the company had issued "watered" stock. William Jennings Bryan and other counsel for the public interests argued for current or reproduction costs. At that time the current cost happened to be less than original cost.

The court upheld the fair-value concept by stating that many elements of value had to be considered in arriving at the figure to be used as a rate base. Among the elements were original cost and current or reproduction cost. The court, however, failed to prescribe a formula to show the weight which should be given to each item. Instead, it said that in order to ascertain the value, ". . . the original cost of construction, the amount expended in permanent improvements, the amount and market value of . . . bonds and stock, the present as compared with the original cost of construction, the probable earning capacity of the property under particular rates prescribed by statute, and the sum required to meet operating expenses are all matters for consideration and are to be given such weight as may be just and right in each case."

Another step in the quest for a definition of fair value came in 1926 when the Supreme Court handed down its decision in the case of *McCardle* v. *Indianapolis Water Co.* (*2*). That case was heard at a time when a temporary plateau of prices had been reached after a long, steady rise following World War I. The court said: "When a court declares that the rate base shall be the *value*, instead of the historical cost or the amount prudently invested in the enterprise, it selects the standard for measuring the property on which compensation is to be paid. . . ."

Most commissions interpreted that decision to mean that current or reproduction cost was to be used as a major criterion of value for the purpose of ratemaking. Consequently, many commissions used estimates of reproduc-

tion cost as almost the sole measure of value during the decade following the court's pronouncement.

For the 40-year period following the *Smyth* v. *Ames* case the decisions of the courts and commissions tended to crystallize to the point that some of the original points of the fair-value concept were omitted. For example, the market value of the utility's outstanding securities and its probable earning capacity were hardly ever used in making a determination of value. That left two major items on which commissions and courts placed their chief reliance: the original cost to the present time and the present cost of replacing the property. The Supreme Court, however, quite uniformly held that fair value was not necessarily identical with either the original cost to date, the present cost of reproduction new, or the present cost of reproduction less depreciation.

Accounting in Regulation

Many theories of applied economics were rudely shaken during the depression of the 1930's and the view regarding utility regulation did not escape the general upheaval. A group of accountants in key positions perceived that the time was ripe to advance the cause of accounting in regulation and they devised a new system for the classification of public utility accounts which was related primarily to original cost. This cost was defined as "the cost to the person who first devoted the property to public service," whether the present owner or a predecessor. Some utility attorneys have been heard to refer to this—rather bitterly—as "aboriginal" cost. Other utility personnel, remembering their high school history, say that on such a cost basis Manhattan Island would be entered on the books today at a value of $24.

The new classification of accounts based on original cost soon went beyond a mere method of bookkeeping and, with the Federal Power Commission leading the way, the new book original cost—depreciated—became the rate base. As might be expected, the public utilities did not accept this new concept and the Natural Gas Pipeline Co. of America took the Federal Power Commission to the Supreme Court in 1942 (*3*). The court decision stated that "The Constitution does not bind rate making bodies to the service of any single formula or combination of formulas. Agencies to whom this legislative power has been delegated are free, within the ambit of their statutory authority, to make the pragmatic adjustments which may be called for by particular circumstances. . . ."

In the following year, the Supreme Court, in the case of the *Federal Power Commission* v. *Hope Natural Gas Co.* (*4*), reaffirmed its view in the Natural Gas Pipeline Co. of America case and went further to say that the means of establishing rates is unimportant as long as the end result is reasonable.

These decisions seemed to free the state commissions of a need to consider anything other than original cost, except as they might be bound by their own state laws. Pursuant to that line of reasoning, many fair-value states operated on the assumption that the major, if not the only item, to consider in a determination of fair value was net original cost. For instance, the Maryland commission has been hewing very close to the line of depreciated original cost in its decisions over the past 10–12 years. In 1952, the Chesapeake and Potomac Telephone Co.

took the commission to the Maryland Court of Appeals because the rate base established by the commission was less than 3 per cent above net original cost. The Court of Appeals upheld the commission, ruling that although reproduction cost is a proper factor to be considered in establishing a rate base, the weight to be given to reproduction cost remains within the discretion of the commission.

Although this discussion is concerned primarily with water rate cases, most of the comments thus far have been on other kinds of public utilities. The reason for this is that the law, making no distinction between kinds of public service companies, applies the same procedures to all.

NARUC System

Many states have adopted the uniform system of accounts for water utilities as recommended by the National Association of Railroad and Utilities Commissioners (NARUC). That system is based on original cost, defined as the cost of ". . . property to the person first devoting it to public service." Therefore, because the accounts for water systems are kept on the same basis as those for other types of public utilities, the commissions have the same starting point on which to establish a rate base for water utilities.

As prices keep spiraling upward and the value of the dollar continues on its downward path, more and more pressure is put on commissions to give added weight to present costs. This takes the form of requests for higher rate bases or, at least, for the use of current costs in the calculation of depreciation.

There has been much discussion in recent years of "attrition" to property brought about by calculating depreciation on original cost. Many arguments have been advanced in support of the contention that depreciation should be calculated on the basis of current or replacement cost. It must be confessed that the proponents of this view are very persuasive, especially when it can be demonstrated that the amount recovered through depreciation charges on an original-cost base will cover only 50–60 per cent of the cost of the replacement. This subject, however, is more properly in the area of depreciation and revenue, which demands separate consideration and is outside the scope of this discussion.

Current Costs

More and more commissions are succumbing to the pressure to give more recognition to current costs. Some have been ordered to do so by legislatures or courts, and others have simply had a change of viewpoint. A recent survey indicates that in 1947 there were 30 state commissions using a net original-cost rate base and only 8 states recognizing any element of current value. In 1957, there were still 28 states using only original cost, but 17 required some recognition of current costs.

The states which do give recognition to present prices may use any one of a number of methods to determine the value at current costs. An expensive and time-consuming way is estimation of the cost of reproduction by setting up a hypothetical organization to reconstruct the property at current costs of labor and material.

Use of Index Numbers

More recently, both commissions and courts have given recognition to the "trending" method of converting original costs to current costs by the

use of index numbers. If the index numbers are carefully calculated and are based on relevant material, then a very good case can be made for their acceptance in trending costs. The principle is involved in converting figures from one base to another by the use of conversion or index numbers probably familiar to all—as is the fact that such a method can be applied in a comparatively short time. From the standpoint of time alone it is easy to see why the trending method has become so popular with those bodies interested in arriving at the current value of property which was installed in previous years.

In several rate cases before the Maryland commission in recent years, the utilities have presented studies of current value which were prepared by the use of the trending method. It is of interest to note that one of the first uses of trending in a major rate case was in 1933, when the staff of the Maryland commission used index numbers in deriving the current cost of the property of the Chesapeake and Potomac Telephone Co. of Baltimore. In 1935, that case went to the US Supreme Court on several points as *West* v. *Chesapeake and Potomac Telephone Co. of Baltimore City* (*5*). Among other things, the court had the following comments on the use of index numbers:

> To an extent, value must be a matter of sound judgment, involving fact data. To substitute for such factors as historical cost and cost of reproduction a "translator" of dollar value obtained by the use of price trend indices serves only to confuse the problem and to increase its difficulty. . . . We agree . . . that the method was inapt and improper, is not calculated to obtain a fair or accurate result, and should not be employed in the valuation of utility plants for ratemaking purposes.

In fairness to the court, it should be explained that much of its objection to the use of index numbers was based on the fact that some irrelevant indexes were used in the study. Since 1935, much work has been done on developing more accurate trending methods, and the principle today is widely accepted.

For rate-making purposes, the fair value of a water utility may be original cost, depreciated; current cost, depreciated; or some figure between those extremes. In the final analysis, the fair value will be what the commission says it is, subject to review and final determination by the court.

References

1. *Smyth* v. *Ames*, 169 US 466.
2. *McCardle* v. *Indianapolis Water Co.*, 272 US 400.
3. *Federal Power Commission* v. *Natural Gas Pipeline Co. of America*, 315 US 586.
4. *Federal Power Commission* v. *Hope Natural Gas Co.*, 320 US 602.
5. *West* v. *Chesapeake and Potomac Telephone Co. of Baltimore City*, 295 US 662.

Accumulating a Water Utility Surplus at Rockford, Ill.

Henry S. Merz

A paper presented on Mar. 26, 1958, at the Illinois Section Meeting, Chicago, Ill., by Henry S. Merz, Supt., Water Dept., Rockford, Ill.

IN a literal sense, the Rockford, Ill., Water Dept. resorted to "do it yourself" methods to develop a financial pattern that made accumulation of funds in a surplus account possible. One of the advantages of this pattern is that it is now possible to translate long-range plans into actual construction projects, because funds can either be foreseen or are available.

Previous Practice

Prior to 1946, it was the usual practice, and still is in a great many cities in Illinois, to construct a water department budget, estimate the income from water rents, and put the difference between the expenses and the income into the city's general fund. When the needs of the city were greater than the money in the general fund would support, one way to increase the amount in the general fund was to reduce the water budget. If the needs were really urgent, water rates were increased and the increase transferred to the general fund. This has happened, and perhaps is still happening in other cities, but the author considers it wrong for the legislative body of any city to use its water rates as an indirect method of levying taxes.

Present Practice

Since most cities have always transferred some money from the water utility fund to the general fund, and it is obvious that a practice of long standing cannot be terminated immediately, it was proposed in 1946 in Rockford to control and limit the diversion.

The control and limiting of water revenues transferred to the general fund was done by ordinance. The ordinance prescribed the form of the water department budget. In addition to the usual items of administration, operation and maintenance, property expense, and debt service chargeable against revenues, there is a nonoperating account charged, which is detailed in the ordinance. This nonoperating account is composed of the following items, each of which can be justified for its inclusion as an expense item in the water department budget:

1. *Return on capital investment.* This is an amount equal to 4½ per cent of that portion of the plant value, less depreciation, which came from the proceeds of the sale of general-obligation bonds. This is in effect a dividend to the customers or taxpayers (for practical purposes they are one and the same), because the general-obligation bond principal and interest was paid from taxation and not water rents.

2. *Payment in lieu of taxes.* This is an amount that is equal to the taxes the city's general fund might have received if the utility were privately owned.

3. *Rent.* This sum is in payment for city property occupied.

4. *Franchise tax.* This is a usual utility charge and reimburses the city for use of the city streets.

5. *Legal expense.* This charge is for the services of the city legal department on a retainer basis.

6. *Hydrant rental.* This sum is a credit against charges 1 to 5, and is applied at the rate of $25 per year for each hydrant.

7. *Drinking fountain rental.* This sum is also a credit against charges 1 to 5, and is applied at the rate of $50 per year for each drinking fountain.

The net of the nonoperating account is the amount of money that is transferred to the general fund and is a justified expense of the Water Department.

1957 Budget

Table 1 shows the figures used in the department budget for 1957 in the nonoperating expense account; Table 2 shows the 1957 water department budget. If more revenue is collected than was estimated, the excess goes into the surplus account (Item 10, Table 2), and is available for the next year's budget. If revenue does not equal expenses, then expenses must be cut back or rates must be raised. The Water Department will ask the city council to approve a rate increase in the Spring of 1958 to cover additional debt service expense for bonds totaling $2,500,000.

The Water Department is relying on public opinion to keep in operation the ordinance establishing its present budgetary system. It has been in effect long enough so that the benefits of the ordinance are visible in the form of more plant, better service, and a more businesslike attitude. It is the author's opinion that the ordinance could only be repealed with difficulty.

TABLE 1

1957 Nonoperating Expense Account

Account	Debit	Credit
1. Return on capital investment, exclusive of revenue bonds (4½% of $3,296,856.96)	$148,358.56	
2. Payment in lieu of taxes (0.54265% of $2,499,457.02)	13,563.30	
3. Rent	2,500.00	
4. Franchise tax	10,000.00	
5. Legal expense	2,500.00	
6. Hydrant rental (1,882 at $25 ea.)		$47,050.00
7. Drinking fountain rental (16 at $50 ea.)		800.00
Totals	$176,921.86	$47,850.00
Less Credits	47,850.00	
Amount Paid City of Rockford	$129,071.86	

TABLE 2

1957 Water Department Budget

Account	Debit	Credit
1. Income from water rents*		$866,000.00
2. Income from sale of property		15,075.00
3. Nonoperating income from hydrants		47,050.00
4. Nonoperating income from drinking fountains		800.00
5. Expense of administration*	$ 93,000.00	
6. Expense of operation and maintenance*	347,500.00	
7. Expense of property improvements*	153,000.00	
8. Nonoperating debt service expense account	158,204.28	
9. Nonoperating expense account	176,921.86	
10. Surplus account	298.86	
	$928,925.00	$928,925.00

* Estimated.

Determination and Preparation of Rate Increases and Bond Issues

Joint Discussion

A joint discussion presented on Feb. 6, 1958, at the Indiana Section Meeting, Indianapolis, Ind.

Factors Affecting Rate Increases and Revenue Bond Issues—*Garland G. Skelton*

A paper presented by Garland G. Skelton, Comr., Indiana Public Service Com., Indianapolis, Ind.

THE management of a utility will not consider a rate increase as long as there are sufficient earnings and funds to operate and meet any demands for an expansion or improvement program. In the postwar years, however, municipal water utilities often found themselves in a position where they no longer had sufficient funds to meet changing conditions and the impact of inflation. Inflation has had a serious effect on water utilities. In many instances utilities have had to grant wage increases and retirement pensions. The cost of materials, for the most part, has also risen from year to year. Consequently, a utility whose rates are based upon 1946 prices, for example, may find that the revenues received from such rates are not sufficient to meet payrolls and material costs, or even the bare needs of operation.

A utility may find that an increasing urban population has created demands for additional services, and that funds on hand plus earnings are not sufficient for the necessary improvements and expansion. In this case, the demand for capital may be of such magnitude that it cannot be corrected by an increase in rates. It may also be necessary to borrow.

A municipal utility may also find itself in a position in which major industries, which have been substantial customers of the utility, decide to move elsewhere. A decline in revenue has substantially the same effect as an increase in expenses to the operation of a utility. The circumstances discussed, and numerous others of a similar nature, would make it necessary for a municipal water utility to seek relief in the form of higher rates.

A utility may have revenue bonds outstanding at a higher rate of interest than could be obtained today. Interest rates in the past several months have been too high to permit, in most cases, any refinancing for the benefit of interest payments; however, present signs indicate that another period of low interest rates might well be approaching. It could be economically beneficial to utility ratepayers to refinance outstanding bonds in order to benefit from a better interest rate. Often, however, this process is compli-

cated by the various restrictions which exist regarding the calling in of outstanding bonds. Before seriously considering any move of this kind, the author suggests that a reliable bond counsel be consulted as to these restrictions, and further, that the advice of those experienced in the marketing of bonds be sought.

The refinancing of outstanding bonds might well be coupled with the issuing of additional bonds to secure funds for the payment of an improvement and expansion program. For example: a utility needs $500,000 for expansion and improvement, and has $200,000 in bonds outstanding. Instead of issuing $500,000 in second lien bonds, the utility issues $700,000 in first lien bonds, thereby securing the necessary capital and refunding its outstanding bonds. Second lien (or junior) bonds are not as attractive to the investor as first lien bonds; therefore, they require a higher interest rate.

"Pay-as-You-Go" Plans

Some municipal utilities have found that their program for expansion and improvements could be fulfilled if they had additional capital to invest each year over a period of, say, 5 years. If the needs of the utility for expansion will require a capital outlay of $500,000 over the next 5 years, this sum can be raised by securing a rate increase to provide an additional $100,000 a year, with the money specifically earmarked for expansion and improvements. In order to do this, however, the utility must be of substantial size. The effect upon the rates to the customers must be considered, and this effect would usually be substantial. In most cases, the rates would have to be too high in order to finance a pay-as-you-go program. Securing capital with revenue bonds is more feasible in 99 per cent of the cases.

Financial Needs

The cost to the consumer should always be the first and last thought in the mind of everyone who is responsible for the operation and regulation of a utility. From the consumer's pocket come the funds for the very existence of the utility. The rates must, therefore, be kept as low as possible.

A simple test can determine whether a rate increase would be justified for a utility that is not planning to issue bonds: the utility has revenues of $100,000 a year; operating expenses are $75,000, and depreciation accruals charged to expenses are $15,000; $75,000 plus $15,000 makes a total expense of $90,000, leaving $10,000 a year in net income. Ten thousand dollars a year would, in most cases, be sufficient to provide the utility with funds to make the necessary current additions and services, and other minor improvements, and to continue this utility in a sound operating condition. If, however, the utility had operating expenses of $95,000 a year, then $95,000 plus $15,000 would equal $110,000. The income statement of the utility should then show a deficit of $10,000 a year.

In this latter case, it is possible to imagine that a utility with revenues of $100,000 and operating expenses of $95,000 has a surplus of $5,000. This may be done by not adding depreciation to operating expenses. That, however, is a very unsound practice. The $15,000, in this example, represents property *used up* in the course of a year. A utility which went from year to year imagining that it had a surplus would eventually find that its plant was worn out and it had no funds for rebuilding or replacement. Reve-

nue bonds would then probably have to be issued, thereby penalizing future ratepayers by forcing them to bear the interest charges on these bonds. Many Indiana cities have, in fact, operated their utilities on this very basis in the past years. A great many cities have decided that the surplus created by ignoring depreciation could be transferred to the city treasury, thereby reducing tax rates. This has been a very popular approach and is politically expedient. Cities have actually boasted that they were tax-free, that government was financed by revenue from the utilities. The author contends that no city operates tax-free. In the cities which operated as described, not only have the ratepayers paid for the use of the water, but they have also paid for all other operations of municipal government. The municipal utilities of these cities are today burdened with bonds which they had to issue to replace their plant, and the ratepayers are paying the interest on those bonds. The ratepayers are thereby being charged higher rates as a result of too low rates in past years. Fortunately, the trend of thinking today is no longer along those lines. Utility management now tends to be realistic as to the cost of operation. The entire problem is, of course, complicated by the fact that construction that would, in many cases, have cost $1,000,000 in 1946 would probably cost $2,000,000 today.

If outstanding revenue bonds are taken into consideration, a utility may calculate its annual financial needs as follows: operating expenses, $100,000; depreciation, $15,000; payment of principal and interests on bonds, $100,000 —a total of $215,000. A further sum for coverage, an amount allocated annually to the bond and interest fund in excess of the principal and interest requirements, should be added to the amount set aside for bonds. Coverage is a very necessary item; revenue bonds cannot be sold unless ample coverage is provided. In the opinion of the author, coverage should be 25 per cent of the sum devoted to bonds at a minimum, which would mean $25,000 in this example. The total financial needs of this utility would, therefore, be $240,000 per year.

In addition to these bare requirements, sufficient funds should be available to ensure some safety margin for changing conditions. It is the author's belief that, in most cases, operation and maintenance should be provided for by a safety margin of 15 to 20 per cent above actual requirements. Coverage constitutes a safety factor in servicing bonds.

Securing Bonds

There are two basic laws pursuant to which revenue bonds may be issued.

1. Revenue bonds may be secured by net revenues; that is to say, the revenues remaining after the payment of operating expenses. All net revenues are pledged to secure and pay the principal and interest of the bonds. Under this plan a utility would need operating expenses, plus bond payments, plus coverage. The rates must be so set that they will produce this amount of money.

2. Revenues may be channeled into three different funds: operation and maintenance, depreciation, and bond and interest redemption. Under this plan, the utility management must know how much will be required for operating expenses, how much for depreciation, and how much for bond and interest payments, plus coverage. The bonds are secured not by the net revenues, but by a certain percentage of total revenues allocated to the bond and interest redemption account. To

determine rates under these conditions, the total of the requirements for operation and maintenance, depreciation, bond and interest payments, and coverage is found. Rates would have to be set to produce this amount of revenue.

Consultation

When the management of a utility wishes to petition for a rate increase or a bond issue, it is important that competent professional assistance be obtained. A water utility will naturally retain the services of a qualified engineer; his advice will make it possible to plan construction in the most economical way. The services of a qualified bond counsel, and of someone with experience in utility rates and financial showings to the public service commission and prospective bond buyers should also be sought. The commission cannot be expected to approve either rate increases or bond issues unless their need and feasibility are clearly proved.

"Package Deals"

A utility may be approached by a firm or an individual offering a "package deal" (sometimes called a proceedings contract) for bond issues. This may involve selling the bonds, securing legal advice, working out rates, and other services, in return for a percentage—anywhere from 1½ to 4 per cent—of the total bond issue. Such firms or individuals may even falsely claim to have an "inside track" with the public service commission. A utility should examine any such offers with the greatest care. When revenue bonds are properly presented and adequate financial showings are made, they sell themselves. It is the opinion of the author that the services performed under a package deal contract may cost a utility an additional ⅛ to ¼ of one per cent in interest rates on its bonds. The public service commission will carefully examine any such contract.

Records

All the preparation for rates and bonds must begin with the records of the utility. If the records are not available, the engineer and accountant are forced, in many cases, to make estimates, which, by their very nature, cannot be entirely accurate. The Indiana Board of Accounts and Public Service Commission both require a water utility to keep and maintain records that will be perpetual in nature and specifically designed to meet the needs for daily operation and management. Such records will be ample to give sufficient information as a basis for making studies and preparation for a rate case and a bond issue.

One of the principal errors that is committed by a municipal water utility is in recording its cost of assets. Many times such items as meters and mains are charged to expense, and thereby reduce the net income. Where this condition exists, a casual look at the income statement might indicate that the utility was not making money, but a complete analysis of the charges to expense might reveal that it had ample income and did not need a rate increase. It is very important to maintain accurate records after issuing bonds. There has been great concern among the purchasers of water utility bonds in Indiana because of erroneous reports submitted to them. The reports by the utilities will often indicate that they are not making money, not even enough to service their bonds. The true picture, upon analysis, frequently is that they *are* making money and *can* service the bonds. An incorrect statement has an adverse effect upon the marketability of any future bonds.

Preparation for Rate Increases and Bond Issue Hearings—*Clyde E. Williams*

A paper presented by Clyde E. Williams, Cons. Engr., South Bend, Ind.

There are a number of steps that should be taken in preparation for a rate increase and bond issue hearing. The utility engineer is in a good position to assist the municipality in this preparation.

The most natural customer for an engineer's services in preparing for a rate hearing is a municipality which has operated its water works at a deficit for a number of years, at least long enough to be on the verge of defaulting on its bond payments. It is also helpful if the municipality has a new administration. An administration which has been in office for some time will tend, even though it may realize that its water utility is not being efficiently managed, to try and get by without public criticism. A newly elected official may, on the other hand, be more eager to serve his constituents and fulfill his campaign promises.

Preliminary Investigation

As the first step a preliminary investigation should be made to determine the adequacy of the existing facilities. A report on this should be prepared for the governing body to study and discuss, if necessary, with other citizens, businessmen, civic organizations, or individual consumers. The investigation should determine the adequacy and quality of the existing supply. If it is not adequate, new sources of supply should be investigated; if the quality is poor, treatment studies should be made. The investigation should also determine the adequacy of the pumping facilities, the type of controls, reliability of the equipment in case of emergency, and whether additional pumps should be added. If treatment is already provided, the treatment facilities should be studied, including:

1. *Plant expansion.* The plant should be investigated to determine whether it provides sufficient treatment, and whether new and improved equipment and techniques might be available.

2. *Personnel.* The number, quality, and training of the personnel should be examined.

3. *Chemical uses and equipment.* The chemical facilities should be studied to ascertain whether they are adequately fulfilling their function.

A study of the distribution system to uncover improper sizing of mains for fire flows, dead ends, and new areas needing main extensions, fire hydrants, meters, or valves should be made. The study would also include sufficiency and location of ground or elevated storage.

A study of revenues and expenses for the past few years may reveal a need for additional funds for the present method of operation. This should be included in the investigation.

The report of the investigation should summarize the existing water utility facilities. In many cases they will present a very surprising picture to the governing body. The report should record the population and the number of consumers for past years, and forecast future growth. It should also forecast the water requirements, both present and future, for domes-

tic and industrial use and for fire protection.

If the investigation indicates a need for improvements, the report should recommend the improvements to be made, giving alternatives where possible, and outlines of the proposed design criteria.

A preliminary estimate of the construction costs should be made by items or segments of the work to enable the municipality to determine the relative value of the work, and to delete portions, if necessary. The other expenses, such as land, engineering, auditing, legal, administration, and advertising, should be added to the construction costs to arrive at a total estimated project cost.

The report should analyze the annual operating expenses of the new works and forecast the total revenue needed to operate the utility with the new improvements, to amortize the cost of the improvements, and to provide a reasonable amount for depreciation or replacement.

When the report is completed, it should be presented in detail to the municipality. Each item of the report should be discussed fully, and the recommendations considered in their order of importance. Sometimes, portions of the report will be published in the local papers or informal ballots sent to each consumer.

Plans and Specifications

The next step by the engineer is the preparation of detailed plans and specifications of the work authorized by the client. The plans and specifications should be submitted to the state board of health for review, recommendation, and approval. The client must then finally review and approve, or authorize any changes in the plans and specifications that he wishes made.

When the plans and specifications are accepted and approved, the engineer assists in advertising for bids, sends plans and specifications to contractors, aids in tabulating bids, and helps to select a contractor and equipment based upon the best bid received.

Final Steps

From this point the engineer's services are in support of services by the client's attorney, the auditor or utility accountant, the bond counsel, and the public service commission. The engineer determines the final project cost based upon the bids taken, and the report is revised to indicate the amount of bond issue needed, and the rate increase necessary to amortize the bonds, operate the improved water utility, and provide a reasonable amount of funds for depreciation and additions. The revised report will show the increase in operating expenses, the original cost of the existing plant, and what would be a reasonable amount of depreciation for the new works. The engineer provides whatever assistance he can to the accountant and the attorneys, and he should be prepared to provide expert testimony at the public service commission hearing on the engineering phases of the work.

If favorable consideration is granted by the public service commission following the hearing, the engineer assists in the preparation of a bond prospectus by supplying information contained in the report, if necessary. He may also furnish additional engineering information to prospective bond buyers as requested. He also usually attends the bond sale conducted by the city or town clerk. Following the bond sale, the engineer performs the duties authorized by the client in the supervision of construction.

Distribution Losses and Meter Repair Practices

Joint Discussion

A joint discussion presented on Oct. 16, 1957, at the Southwest Section Meeting, Oklahoma City, Okla.

Detecting Lost Water at Dallas—*Henry J. Graeser*

A paper presented by Henry J. Graeser, Supt., Water Works, Dallas, Tex.

MUCH has been written and spoken on the subject of lost water and its detection. The continual popularity of the subject, however, indicates that much work still needs to be done in perfecting the methods by which lost water is detected. Almost any well operated system which is 100 per cent metered can account for 85 per cent of the water pumped. Only with intensive effort, however, can 5 per cent be taken off the remaining 15 per cent, and no one in the field has accounted for 100 per cent of water production on a distribution system with more than 1,000 mi of mains.

Some of the areas where water can be lost, not in order of importance, include: [1] fire fighting; [2] street flushing; [3] construction work; [4] joint leaks in mains, valves, and services; [5] main breaks; [6] stolen connections; [7] lost accounts or unmetered services; [8] underregistration of domestic meters or incorrect registration of master meters; and [9] fire hydrant valves.

In Dallas, some of these extraneous uses of water have been analyzed and the following information has been compiled.

Item	Use gal/year
Street flushing	84,000,000
Fire fighting	2,909,000
Park watering (unmetered)	87,000,000
Total	173,909,000

There are many other uses, such as hauling of water from fire plugs and jetting of trenches, on which there is no record. Judging from the above uses, however, the actual percentage of lost water through these causes probably amounts to about 2 per cent of the total pumpage in Dallas. The main areas through which this problem can be attacked then seem to lie in distribution losses and underregistration of meters. These seem to be the areas which most authors on this subject have discussed. This article will describe briefly the experience in these two areas in Dallas and the policies which are now being followed, based upon, of course, the value of lost water.

Leak Investigations

For the last 5 years Dallas utility officials have kept an accurate record of the number of leak investigations made by the leak detection crew and have attempted to estimate the amount

TABLE 1

*Dallas Water Billing, 1954–55**

Accounting Code	Class of Consumer	Accounts				Quantity of Water Billed			
		District 99	Districts 1–21	Total	Per Cent of Total	District 99 *mil gal*	Dists. 1–21 *mil gal*	Total *mil gal*	Per Cent of Total
A	Single family or duplex dwelling (see J & K below)	14	138,251	138,265	88.988	12.9450	13,351.9200	13,364.8650	58.420
B	Commercial & small industrial	294	12,273	12,567	8.087	1,424.7040	3,186.7540	4,611.4580	20.160
C	Churches & nonprofit institutions	22	662	684	0.440	223.3130	158.7700	382.0830	1.670
D	Rental: Apartments, projects, authorities	29	1,716	1,745	1.123	604.9800	682.6126	1,287.5926	5.630
E	Food processing and bottling, large	33	13	46	0.030	702.2960	13.7458	716.0418	3.130
F	Public authority, other than city of Dallas	51	3	54	0.035	190.1520	0.8504	191.0024	0.830
G	City of Dallas, all installations	9	59	68	0.044	17.9710	33.2008	51.1718	0.220
H	Public schools	161	—	161	0.104	172.4580	0.3794	172.8374	0.760
I	Heavy industry	52	33	85	0.055	1,277.4020	35.7472	1,313.1492	5.740
J	Dwellings with yard meters	3	403	406	0.261	2.0220	81.0062	83.0282	0.360
K	Yard meter accounts	1	1,286	1,287	0.828	26.4180	400.6986	427.1166	1.870
L	County towns	7	—	7	0.005	275.9060	—	275.9060	1.210
Totals		676	154,699	155,375	100.000	4,930.5670	17,945.6850	22,876.2520	100.000

* Fiscal year ending Sep. 30, 1955.
† Industrial and large commercial.
‡ Residential and light commercial.

of wastage in the various leaks which have been located. These are categorized as to main leaks, fire hydrants, service leaks, valves, and property leaks. Fire hydrants are tested first, as these are most often guilty of leaking. Reviewing these different types of leaks, officials have tried to concentrate on those which were hidden, on the assumption that they would have found any obvious leak, such as a fire hydrant or surface leak. They have also discounted the amount of lost water located through the leak detection program on customer services which would have been metered and paid for. Total wages for leak detection over the last 5 years has amounted to $21,291, or about $5,322 per year. It is estimated that hidden leaks found in the distribution system, if continued over a 5-year period, would cost the city $83,882 for the cost of power and chemicals only for the treatment and pumpage of water. This figure has omitted any capital, maintenance, or personnel costs involved in production. On this basis, assuming that no work at all on leak detection had been done in the last 5 years and the leaks found had accumulated to this date, in 1 year at the accumulated rate, the cost of chemicals and power would amount to $16,776. This is based on an estimated loss in the amount of 882 mil gal per year which would be occurring by now had repairs not been made. These figures certainly indicate the economic feasibility of a leak detection program in any city. It is significant, however, that 882 mil gal is only 2.8 per cent of annual primary pumpage in Dallas.

At the present time, total lost water in the system has amounted to around 3½–4 bil gal per year, with an average for a 5-year period of 15 per cent of the total of primary pumpage. According to the Cast Iron Pipe Research Association the probable distribution loss does not exceed 3 per cent from deterioration of mains or joint leaks. This would mean a normal loss of 930 mil gal per year, which, when added to miscellaneous losses, accounts for 5 per cent of the lost water, and the utility has prevented an additional loss of 2.8 per cent by system maintenance. Without a leak detection program, undetected water would amount to about 17.8 per cent by now. As a further check, however, officials applied a 24-hr loss of 50 gal/in. of diameter per mile of pipe to the distribution system. This indicates a total annual loss of 392 mil gal, or roughly 1.27 per cent of primary pumpage loss. Therefore, total losses accounted for come to about 3.8–5 per cent, leaving two-thirds or more of the lost water which can be attributed largely to underregistration by water meters and other undetected losses.

Improper Metering

The loss from improper metering is not necessarily the biggest loss, but it probably is the most costly. Table 1 shows the breakdown of accounts in the city and the amount of water metered to each. These data were for September 1955, and as of that date there were almost 160,000 ⅝-in. meters in service.

In 1940, K. F. Hoefle, former superintendent of the water department, established a basis for maintenance of some of the older type of meters then in service, based on studies made by D. R. Taylor, plant superintendent of the water department in Roanoke, Va. Taylor had concluded that the water used in homes broke down into about the following classifications:

Rate *gpm*	Percentage Used
0.25	5
0.5	6
1.0	8
2.0	31
5.0	40
10.0	10

Using this same percentage breakdown and assuming that a meter would register only 65 per cent accuracy at ¼ gpm and would register 98–100 per cent on flows from 1 to 10 gpm. On this basis a policy was established to repair the older meters to that accuracy standard, but requiring a 90–95 per cent accuracy on newer meters repaired in the meter shop.

At that time, however, this loss on a 3,000-gpm account amounted to 10 cents per meter per year. Rates have gone up and so has usage. That same meter is serving a 12,000-gpm account, and 3,000 gal of water costs $2.70 instead of $0.80. Thus, a meter registering 70 per cent accuracy at ¼ gpm versus a new meter at 90 per cent accuracy could underregister a 12,000-gpm account by as much as 1,440 gal per year or, at 50 cents per 1,000 gal, 72 cents a year. A. P. Kuranz, in

TABLE 2

Test Results on ¾-in. Meters at Dallas

Meter No.*	Accuracy of Flow—*per cent*					
	10 gpm	5 gpm	2 gpm	1 gpm	½ gpm	¼ gpm
6-Year Service or More						
125011	100	100	100	100	96	93
126633	98	98	98	98	92	96
128024	100	100	100	100	99	99
129191	100	100	100	94	92	90
136009	100	100	100	100	99	98
137391	100	100	100	100	99	98
122934	100	100	100	100	100	99
123032	100	100	100	100	100	99
36628	100	100	100	100	98	98
35342†	100	98	100	94	94	—
8-Year Service or More						
61349	100	100	100	99	90	90
86397	100	100	100	100	92	78
111178	100	100	100	100	99	98
36241	100	100	100	100	100	94
91695	100	100	100	100	96	66
42007	100	100	100	100	99	96
35802	100	100	100	100	98	96
35831	100	100	100	98	94	88
33355	99	99	98	90	88	78
10-Year Service or More						
72831	100	100	100	99	99	98
94400	100.5	100.5	100.5	100	99	99
89020	100	100	100	100	99	98
42027	100	100	100	100	78	—
83890	100	100	100	99	—	—
16679	100	100	100	98.5	98	98
21289	100	100	100	100	96	96
7130	100	100	100	100	98	96
21121	100	100	100	99.5	96	80
45748†	100	100	100	99	90	78
12-Year Service or More						
73016	100	100	100	99	98	98
73071	100	100	100	100	99	98
62577	100	100	100	100	96	96
17834	98.5	98.5	99	98.5	97	96
20971	100	100	101	100.5	98	94
12119	100	100	100	100	98	96
22463	100	100	100	98	96	96
47821†	90	90	88	82	—	—
51865†	100	100	100	98	90	—
45896†	100	100	100	98	98	—

* Indicates relative age.
† Substandard.

1942 (*1*), revised these estimates to as much as 13.6 per cent at ¼ gpm and below.

Rate of Flow *gpm*	Water Used *per cent*
less than ¼	9.1
¼	4.5
½	1.8
1	5.0
2	11.8
4	52.4
6	14.7
10	0.7

On this basis a 12,000-gal per month account would use 1,632 gal at a rate of ¼ gpm and below. A meter registering 70 per cent instead of 90 per cent would not register 326 gal per month, resulting in a loss of $1.95 a year at the present rates. This loss will now economically justify replacement of these old units. Concerning the problem of lost water, there are now about 40,000 meters of the outmoded type. These units could underregister as much as 40,000 times 326 gal per month, or 13,040,000 gal per month and 156,480,000 gal per year. Although the loss is comparable, volumetrically, to water lost from other causes, the loss by underregistration represents a larger cash loss; it is water that has been "sold," whereas losses along the line are those of cost, power, and chemicals only.

Maintenance of Meters

As to the newer meters, the question is just what period of maintenance should be established to assure they will continue to register 90 per cent and above at ¼ gpm. Originally, Dallas established a routine change-out every 7 years on all water meters in the city, but soon found that this was far too often. Recently, a number of meters were pulled at random throughout the system, based on years of service (Table 2). On all meters of modern manufacture, it was found that in none of 6 years' service was the registration below 90 per cent, and the average was nearer 98 per cent. Substandard meters are indicated in Table 2. After 8 years of service, one meter of a group of ten registered as low as 66 per cent, but five registered better than 90 per cent at the ¼-gpm rate. It is interesting to note that meter No. 35802 was purchased in 1923 and has been into the shop only three times in its life. Meter No. 12119 was purchased in 1915, and has been in the shop for repairs four times since its purchase; No. 7130 was purchased in 1913 and has been in for repairs four times. Taking, then, a group of ten more meters which had been in service 10 years, two of this group were stuck and would not register at all at ¼ gpm, but six of the meters measured 96–99 per cent at ¼ gpm. Many managers, in making their own investigations, have found similar results. Seemingly, most meters will operate 12 years or more under satisfactory conditions of water quality and still retain a high degree of accuracy at low flow as well as at higher rates. At the same time, in Dallas, more than 25,000 meters are removed each year because they are stuck or need various kinds of repairs.

Of the March 1957 removals from the system the average service was only 4 years, which confirms the necessity for analyzing lost water due to underregistration by another method. The stuck meters, in the Dallas system, fall into two categories: those stuck because of calcium carbonate deposits from the excess lime treatment and those stuck by sand. This problem actually deserves as much attention as the low-flow accuracy requirements of

the meters, as a meter beginning to stick from calcium carbonate deposits will slow down far ahead of the time it actually stops and does not register at all at any rate of flow. Fortunately, most of these come to light due to poor pressure complaints, but the meter readers are also constantly cautioned to be on the lookout for any sudden decrease in water consumption not subconsumption was from $5 to $25 during the period in which the meter was slowing down or beginning to stick. More than 25 typical accounts, under which stuck meters were removed, were found to have losses averaging $5 per account. Analyses, for purposes of shop production, of why meters were brought in for repair showed that in 1 month, when a total of 2,481 meters

TABLE 3

Analysis of Meter Repairs

1957	Total Into Shop	Leaks	Bad Register	Test	Removal	Stuck	Routine Change
March							
Number	2,030	640	335	12	161	714	168
Percentage of total	100	31.5	16.5	0.6	7.9	35.2	8.3
April							
Number	1,907	509	351	10	109	768	160
Percentage of total	100	26.6	18.4	0.5	5.7	40.4	8.4
May							
Number	1,868	539	249	7	88	804	181
Percentage of total	100	28.9	13.3	0.4	4.7	43.0	9.7
June							
Number	2,138	422	382	9	166	855	304
Percentage of total	100	19.7	17.9	0.4	7.8	40.0	14.2
July							
Number	2,409	486	449	15	140	1,063	256
Percentage of total	100	20.2	18.7	0.6	5.8	44.1	10.6
Totals	10,352	2,596	1,766	53	664	4,204	1,069
Per cent	100	25.1	17.1	0.5	6.4	40.6	10.3

stantiated by a vacancy in the house.

At the time of billing, registers are scanned constantly by a clerk looking for both overreads, underreads, or possibly stuck meters. Electronic machines also scan by checking figures each month. It is from these sources that most of the orders for change-outs now come. In reviewing several situations where meters had become stuck, it was obvious that the loss during summer came into the shop, 13 per cent had been removed for stuffing-box or body leaks, 18.9 per cent for bad registers, 2½ per cent for test because of customer complaints, 5.6 per cent because of service discontinuation, 46.8 per cent were stuck, and 12½ per cent were removed on routine maintenance. Of the 46.8 per cent, or 362 meters stuck, 325 were stuck with sand or foreign matter from the distribution system, while 37

were stuck by chemicals. Table 3 shows the results of a 5-month analysis of meter repairs.

These factors are important because they represent lost water and lost money. In addition, they disrupt a program of routine maintenance aimed at repairing old meters which have either been worn or, because of long service, are in need of being overhauled. Many of the annoying change-outs, for leaking stuffing boxes or broken register glasses, are repaired in the field without bringing the meter into the shop at all. But, even so, some of these get into the shop, because field repairs are not practical or inspection work load does not permit inspectors to do this work. The stuffing-box leak can mean inadequate repairs or faulty stuffing-box design, but nevertheless it points to a weak spot in meter construction, which is leading to a large volume of repair.

Concerning the normal overhaul period, it would appear that in many situations, under ideal water and service conditions, a change-out routine on even a 10–12-year basis is not essential with premium type meters. Again, this factor must be tempered by the total volume of water used through a connection under normal conditions. The average domestic consumer in Dallas will use somewhere in the vicinity of 144,000 gal per year, which would indicate that a meter would register somewhere around 1½ mil gal in a 10-year period. Breakdown tests carried on in the shop indicate that this is not an unreasonable amount for a meter to register, and little wear can be noticed in vital parts after this length of run, provided the meter has not been overloaded.

Suggested Analysis

Perhaps it is the wrong approach to the problem to attempt to establish a set routine change-out for meters, since even a new meter only recently installed can be stopped by sand or foreign particles, which has nothing material to do with the service life of the meter. Perhaps more attention should be devoted to a better analysis of meter readings and the possibility of a practical field test for small meters, which will detect low-flow underregis-

TABLE 4

Results of Field Tests on ¾-in. Meters

Meter	Years in Service	Accuracy of Flow—*per cent*	
		¼ gpm	10 gpm
1	2 or less	83	no test
2	2 or less	75	96
3	2 or less	122*	100
4	2 or less	98	98
5	2 or less	100	100
6	2 or less	100	99
7	3	100	99
8	3	75	100
9	4	98	100
10	5	65	98
11	5	99	100
12	6	—	93
13	7	98	100
14	8	89	84
15	8	—	94
16	8	100	103
17	9	99	100
18	10	82	100
19	11	98	100
20	12	100	100
21	†	98	100
22	†	20	100
23	†	49	100
24	†	163*	101*
25	†	100	100
26	†	100	99
27	†	97	92
28	†	98	99
29	†	99	104

* Property leaks or customer usage.
† Records not available.

tration. In a city the size of Dallas, three men could cover the city in a period of about 4 years, simply testing meters on low-flow rates to see if they registered accurately at ¼ gpm. On one random field test of 29 accounts (Table 4) several meters were found to underregister on ¼ gpm, and they needed repairs. Although this test is not accurate, it provides a way of finding the real culprits without the necessity for wholesale removals. Naturally, this involves all the problems of service discontinuance to customers and entrance to the premises. In addition, use of water by the customer whose lines have leaks will affect the test. Some approach of this nature seems to be in order, however, rather than a routine change-out period. Again, main flushing and sand traps may be in order, to reduce the amount of foreign matter getting to the meters.

Conclusions

Whatever program is adopted, the experience in Dallas certainly indicates that, whether meters be 9, 6, 8, 10, or 12 years of age, with a clean water and normal service conditions, they can be depended upon to retain a high degree of accuracy throughout their range of flow.

The lost-water problem can best be attacked by:

1. Leak detection on main line with electronic equipment
2. Aquaphone on fire hydrants and services as a part of other routine work
3. An active field testing of primary and customer metering
4. Office procedures to detect stuck meters and effect prompt change-outs
5. A routine change-out program on water meters based on realistic maintenance schedules
6. A highly accurate domestic water meter at low flows and the junking of units that will not deliver the required accuracy.
7. Meter shop repair procedures which assure a new-meter condition in repaired units.

Reference

1. KURANZ, A. P. Meter Maintenance Practice. *Jour. AWWA*, **34**:117 (Jan. 1942).

——Meter Repairing at Fort Worth—*W. Ralph Hardy*——

A paper presented by W. Ralph Hardy, Asst. Director, City Water Dept., Fort Worth, Tex.

The meter repair shop of the Fort Worth water system is a part of the new service facilities. These facilities were completed in May 1956, at a total cost of $574,300. The service facilities are centrally located near the downtown district. The 15-acre site provides ample space for the storage yard, warehouse, offices of the distribution superintendent and the construction engineer, survey parties, assembly and locker rooms, radio dispatcher, filling station, equipment maintenance shops, parking, and the meter repair shop.

The new meter repair shop provides few unusual features, but it represents a great step forward in the operation of the Fort Worth Water Dept. It has been provided with modern equipment and has one unique feature for this era of rapid growth—it was larger than was really required at the time it

was first occupied. It will be described briefly in order to clarify the various procedures of meter repair.

The portion of the shop building occupied by the meter shop (Fig. 1) is 50 × 65 ft, exclusive of the unloading dock and the sanitary facilities. The masonry building has concrete-tiled inside walls, with glazed tile wainscoting and a plastered ceiling. Fluorescent lighting and central heating are provided.

Repair Facilities

The shop layout was designed for the repair of 200 meters per day, using the assembly line procedure. It was equipped to handle about 100 per day, and currently some 65 meters are being repaired daily. The repair facilities include the following (Fig. 1):

1. Unloading dock and meter wash rack

2. Sand blast room, 9 × 12 ft, equipped with a 60-in. hood-type machine and a bag-type filter for exhaust

3. Acid treatment room, 9 × 13 ft, with rubber-covered table tops and sinks (Acid fumes are removed by mechanical exhaust. Acid wastes are neutralized in a vat containing marble chips, which is located outside the building.)

4. Meter breakdown bench and reassembly tables, equipped with air-operated impact wrenches and screw drivers and containing sinks with hot and cold water

5. Parts repair benches, with accessible grinders and a drill press

6. Testing equipment including two racks with space for twelve ⅝-in. meters each and one rack for four ¾–2-in. meters (Each of the small racks is equipped with 0.5-, 1-, and 2-cu ft capacity tanks and the larger rack has 1-, 10-, and 20-cu ft capacity tanks. The hydraulic clamp-type series testers have rate-of-flow indicators. They may be operated manually or automatically, with the electric cut-off valves.)

7. Paint room, 8 × 10 ft, equipped with mechanical exhaust (Meters are spray-painted with bronze paint.)

8. Miscellaneous parts storage, movable carts, offices, and records space

9. Sorting table for meter setters

10. Facilities, such as air compressor, heating system, warehousing, and fork hoist (shared with the distribution division shops).

TABLE 5

Meter Repairs at Fort Worth, Tex

Fiscal Year	Active Meters in System	Meters Set	Meter "Outs"*		Meters Exchanged	
			No.	*per cent*	*No.*	*per cent*
1956	93,300	30,614	26,954	28.9	4,222	4.5
1955	89,640	31,757	27,140	30.2	4,274	4.8
1954	85,117	28,256	24,945	29.3	4,928	5.8
1953	81,806	29,587	24,590	30.0	4,480	5.5
1952	76,809	25,603	19,187	25.0	3,610	4.7
1951	70,393	24,003	16,638	23.7	5,988	8.5
1950	64,647	19,709	14,921	23.0	3,847	6.0
1949	59,859	14,643	11,606	19.4	3,933	6.6
1948	56,822	14,747	10,689	18.8	4,260	7.5
1947	52,764	14,256	9,452	17.9	4,293	8.1

* 70 per cent of these are actually taken to the shop; the remainder are read and left on as set for the new user.

Operating Procedure

The meter repair section is under the supervision of the commercial manager whose office is at the city hall. The meter maintenance supervisor is provided an office at the shop. He is responsible for the operation of the shop and also the supervision of the meter setters who work out of the shop. In order to facilitate the understanding of operation of the meter shop, a brief outline of procedures and policies is necessary.

There are at present approximately 96,000 meters serving customers in the

Fort Worth water system. The cast-iron meter boxes and lids are not locked. Meters are removed from all inactive accounts. Eight meter setters, provided with pickup trucks, remove, set, and exchange meters. A meter setter also repairs leaks occurring in the meter box, adjusts box heights, and installs resetters where necessary. The meter repair personnel include the supervisor (part time), his assistant, eight meter repairmen, and three laborers.

All meters that are removed from service or exchanged (Table 5) are checked into the shop. They are inspected, repaired, tested, and sealed. Some of the meters, however, have been in service for only a very short time. Whatever minor adjustments may be needed are made on the newer meters, and, if the test requirements are met, they are sealed. Approximately one of three meters entering the shop is handled in this manner. These are recorded as adjusted meters,

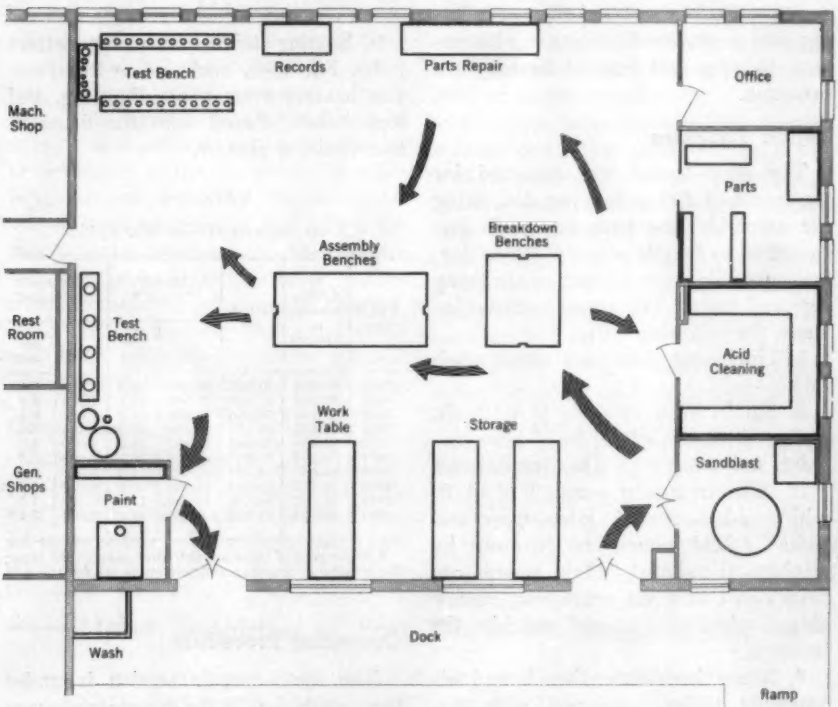

Fig. 1. Meter Repair Shop, Fort Worth, Tex.

Arrows indicate the order of a typical overhaul process, from where a meter is brought in and sandblasted through the final stage of painting. Meters requiring only minor adjustments can be broken down, reassembled, and tested, without going through the other stages of repair.

and they number approximately 700 per month.

Most of the meters are washed, cleaned by sandblasting, completely disassembled, cleaned, checked for worn parts, reassembled, tested, sealed, and painted. About 1,400 meters are repaired each month.

Meter test requirements have only recently been brought up to date. Under the system of operation in the old shop each repairman tested meters repaired by himself. The present procedure provides one man to test all meters passing through the shop. Records of test results have been tabulated over a period of time to determine the test requirements that might be complied with under the present system of operation. These requirements are shown in Table 6.

Data in Table 6 are present requirements, but after more cost and accuracy data have been accumulated, it may be possible to increase the test efficiency requirement on the low flows. Actually more than 60 per cent of all of the repaired meters, $\frac{5}{8} \times \frac{3}{4}$ in., consistently meet the 90 per cent efficiency test on the $\frac{1}{4}$-gpm flow rate. New meters are tested in accord with AWWA requirements (*1*).

The annual cost of operating the meter repair shop, exclusive of debt service and utility costs, is about $85,000. The average cost per each repaired meter is approximately $2.70 for parts, $2.05 for labor, and 35 cents miscellaneous—a total of $5.10. The cost of repairing meters is not individually recorded. The expense of setting and removing is not included in the above tabulation.

The Fort Worth system of operations calls for the removal of meters from all inactive accounts, resulting in approximately 20,000 meters being removed annually as "outs" (those taken from service). This represents 21 per cent of the meters in service. An additional 4–5 per cent of the meters in the system are exchanged and brought to the shop due to some malfunction of the meter (Table 5). The ratio of meters exchanged annually to total active meters has decreased in 10 years from 1:12 to 1:22. The frequent trips through the shop have undoubtedly been a contributing factor to the decrease in the relative number of exchanges. Of the meters exchanged, 60 per cent are exchanged due to a missing hand on the dial and 30 per cent are replaced because of stoppage or suspected slowness. The ratio of out meters to total meters has increased from 1:5½ to 1:3½, caused by better economic conditions, associated with plenty of available housing units. Currently, 45 per cent of the meters removed have been in service 12 months or less, 65 per cent have been in serv-

TABLE 6

Test Requirements for Meters at Fort Worth

Size *in.*	Rate of Flow *gpm*	Test Quantity *cu ft*	Accuracy Limits *per cent*
$\frac{5}{8}$	$\frac{1}{4}$	$\frac{1}{2}$	60 –101.5*
$\frac{5}{8}$	$\frac{1}{4}$	$\frac{1}{2}$	90 –101.5
$\frac{5}{8}$	2	1	98.5–101.5
$\frac{5}{8}$	10	2	98.5–101.5
$\frac{3}{4}$	$\frac{1}{2}$	1	90 –101.5
$\frac{3}{4}$	3	1	98.5–101.5
$\frac{3}{4}$	15	10	98.5–101.5
1	$\frac{3}{4}$	10	90 –101.5
1	4	10	98.5–101.5
1	25	10	98.5–101.5
1½	1½	10	90 –101.5
1½	8	10	98.5–101.5
1½	50	20	98.5–101.5
2	2	10	90 –101.5
2	15	10	98.5–101.5
2	70	20	98.5–101.5

* Very old meters.

ice only 24 months or less, and 80 per cent have been in service 4 years or less.

Registration and Consumption

Meters are not brought in for repairs after a specified number of years of service or after a specified maximum registration. Consequently, some meters have been in service at the same location for many years. A check of the records indicates that as many as 10 per cent have been in service 10 years or more and some have been in service for more than 20 years.

TABLE 7

Characteristics of Fort Worth Tap Water

Item	Analysis *ppm*
Total solids	
Residue on evaporation	226.0
Loss on ignition	10.00
Silica and insoluble (SiO_2)	4.40
Iron oxide (Fe_2O_3)	0.07
Alumina (Al_2O_3)	10.30
Calcium (Ca)	44.40
Magnesium (Mg)	7.60
Sodium* (Na)	20.30
Sulphate (SO_4)	18.10
Chloride (Cl)	27.30
Carbonate (CO_3)	0.60
Bicarbonate (HCO_3)	156.20
Nitrate (NO_3)	0.05
Fluoride (F)	0.30
Total hardness	141.00
pH	8.31
Turbidity	none

* Calculated.

A recent survey of some of the old meters indicated that, in general, the registration was low for low flows and high for high flows.

Meters that had been in service at one location for 15–25 years appeared to have an average efficiency of about 50 per cent at the ¼-gpm rate, 100 per cent at 2-gpm, and 102 per cent at the 10-gpm flow rate.

A few rate-of-flow determinations of customers' meters indicated that about 10 per cent of the daily usage of residential customers is at the ¼-gpm rate or less. The cost of exchanging and repairing the oldest meters would not be repaid by the gain in registration for several years. Nonetheless, it appears that to be fair to all customers the oldest meters should be subject to routine testing, and it is expected that within a short time periodic testing will be standard procedure.

The chemical characteristics of the water supply are considered an important factor in meter shop practices. The relatively good registration of the meters that have been in service more than 15 years is an indication that the quality of the Fort Worth water is not very harmful to the proper functioning of the meters in the system. Results of an analysis of the tap water on Mar. 11, 1957, are shown in Table 7.

TABLE 8

Metered Consumption at Fort Worth, Tex.*

Period	Consumption—*per cent of pumpage*				
	Annual	Dec.	Jan.	Feb.	Avg Dec.–Feb.
1947–51	87.6	90.2	86.6	91.9	89.6
1952–56	88.6	88.0	88.2	91.8	89.4
1947–56	88.2	89.0	87.4	91.8	89.5

* Does not include "percentage accounted for" to cover the estimated use for fires, street cleaning, water for testing and flushing, or large leaks.

The spring flood in 1957 resulted in only a slight decrease in the hardness content of the water. The raw water from Lake Worth is coagulated with alum and lime. A very slight deposition of precipitate forms a film which assists in the prevention of corrosion in the distribution system. This film

has not been unduly harmful to the meters, as substantiated by the previously mentioned tests on the old meters.

Meters larger than 2 in. are tested in the field. An old army ambulance was converted soon after World War II into a large meter repair and test truck. Routine testing of all large meters has not been the practice in past years, but rather tests have been made only when there was some indication of trouble.

The meter repair and testing practices outlined herein have been in effect only since the move into the new shop and, therefore, the results are not yet reflected in the overall efficiency of the system. Rather, the 10-year record as shown in Table 8 indicates efficiencies related to the old repair shop plus the policy of removing meters from all inactive accounts. For the 10-year period, 1946–56, the metered water consumption was 88.2 per cent of the water pumped into the distribution system.

The variable time lag between daily and monthly pumpage quantities and monthly meter readings usually makes monthly comparisons meaningless. Pumpage and usage relationships during the winter months are more constant, however, than during the warm months of widely fluctuating water uses. The metered use for December–February of 89.5 per cent of the pumpage for the 10-year period is an indication that the percentage of water metered in the Fort Worth system is fairly constant.

The 11.8 per cent difference between annual pumpage and metered use includes water used for fire fighting, flushing, jetting of ditches, chlorinating, and testing new mains, plus losses due to large main breaks and the usual distribution system leakage. The expression "percentage accounted for" is not used in Table 8, because of the many methods and bases for estimates. In order that other cities may compare results with the Fort Wayne system, estimates have not been presented for various known but unmetered uses.

A 1 per cent gain in the metered usage, other factors remaining constant, would mean an increase in revenue of a considerable amount. With the better repair facilities it is expected that the overall efficiency of the 96,000 meters will in time improve in some degree. Comparative data that will be available in 5–10 years should certainly be of interest.

Reference

1. Tentative AWWA Standard for Testing Cold-Water Meters—AWWA C705. Am. Wtr. Wks. Assn., New York.

Algae and Other Organisms in Waters of the Chesapeake Area

C. Mervin Palmer

A paper presented on Nov. 1, 1957, at the Chesapeake Section Meeting, Washington, D.C., by C. Mervin Palmer, Head, Interference Organisms Studies, Robert A. Taft San. Eng. Center, USPHS, Cincinnati, Ohio.

ALL surface waters contain numerous kinds of microscopic organisms which grow and multiply and constitute part of the natural flora and fauna of the water habitats. These organisms may be of importance when the water is used as the source of a public water supply. The pH, turbidity, odor, dissolved-oxygen content, and other physicochemical characteristics of the water are all influenced by the microorganisms. In addition, they may clog the intake screen, reduce the length of the filter runs, appear as visible growths in the tap water, cut down the flow in the distribution system, and develop nuisance growths in the shallow margins and inlets of reservoirs (*1*).

The algae are the most abundant and most significant of the interference organisms and are represented by four main groups: the blue-green algae, the green algae, the diatoms, and the pigmented flagellates (*2*). Other interference organisms would include actinomycetes, iron bacteria, protozoa, rotifers, crustacea, copepods, and aquatic worms. The organisms which grow suspended in the water are known as plankton, while other forms may be bottom-dwelling organisms or grow attached to rocks, pipe surfaces, the walls of settling basins, and other substrates.

The Chesapeake area has its full share of problems caused by the algae and other interference organisms. In this review some of the information pertinent to this region has been selected from approximately 50 published articles. Original records of the plankton counts for 1954 made at the Dalecarlia Filter Plant in Washington, D.C., have also been available for study and interpretation (*3*).

Geographical Characteristics

The Chesapeake area comprises the District of Columbia together with the states of Delaware and Maryland. It has a total area of over 13,000 sq mi, considerably more than 1,000 of which are water. The average annual rainfall for the Chesapeake area ranges from 25 to 55 in., and for most of the area it is more than 38 in. This drains into a considerable number of streams, a few lakes, and many thousands of acres of marsh. There are three principal physiographic regions represented: the coastal plain, the piedmont plateau, and the Appalachian Mountain region.

The coastal plain is divided by Chesapeake Bay and encompasses the

entire eastern shore and the western shore as far inland as the fall line. Washington, D.C., Baltimore, Md., and Wilmington, Del., are all located approximately on this line. The soil consists mainly of light to sandy loams which are underlaid with the very old Mesozoic and Tertiary formations. Some lakes and ponds are present, the state of Delaware alone having more than 50 that contain fresh water. Eighty per cent of that state is in the Atlantic coastal plain. A considerable number of rivers and creeks are present, most of them emptying into Chesapeake Bay. Most of these rivers serve as tidal estuaries. The towns and smaller cities, on the whole, obtain their public water supplies from wells rather than from the streams.

The piedmont plateau, as well as most of the coastal plain, is composed of rich farmlands with a loam soil underlaid by crystalline rocks of igneous origin and Paleozoic formations. The larger streams traversing the region are the Brandywine, Susquehanna, Gunpowder, Patapsco, Patuxent, and Potomac. Public water supplies for Washington and its suburban area, Baltimore, Wilmington, and other communities are obtained from several of these rivers either directly or after impoundment.

The Appalachian Mountain region has a rough terrain and is not well adapted to agriculture. The geological formations are largely Cambrian, Silurian, and Devonian. Many of the soils are derived from limestone and sandstone. Water is made available generally by impoundment for the larger communities. Cumberland, Md., obtains its water supply from impoundments on one of the tributary streams flowing into the Potomac River. They are underlaid with limestone, sandstone, and shale (*4*).

The rock layers, the soils, the topography, the agricultural practices, and many other factors influence the amounts and types of growth of aquatic organisms in the streams, lakes, and reservoirs by determining their physicochemical characteristics. Conditions or practices which release nutrients in the water, such as heavy fertilization of adjacent agricultural land and continuous pollution of the water by domestic sewage, whether raw or treated, are particularly influential in stimulating or modifying the growth. Algae and other plants are directly affected by these factors to a greater extent than the animal forms.

Types of Organisms

The algae are of many types and kinds and are present in all bodies of surface water. A limited number of taxonomic studies have been made of the fresh-water algae of the Chesapeake area. Drouet (*5, 6*) has listed many species of blue-green algae for Maryland. Thompson (*7*) reported 20 species of fresh-water dinoflagellates for Maryland. Two of these were new to science and ten were listed for the first time in the United States. The Maryland dinoflagellates belong to seven genera: *Ceratium, Glenodinium, Gymnodinium, Gyrodinium, Hemidinium, Massartia,* and *Peridinium.* Five species were found under ice. The four most abundant species in the state were reported to be *Gymnodinium fuscum, Peridinium umbonatum, Peridinium cinctum,* and *Ceratium hirundinella.* Dinoflagellates are known to be important producers of tastes and odors in water supplies.

Higinbotham (*8*) found in Maryland a green flagellate alga which he

described as the new genus, *Cephalamonas*. Bold (*9*) reported the presence in Maryland of several other green flagellates, all producing an abundant growth.

Comparatively little work of a strictly taxonomic nature has been done on the green algae and diatoms of the rivers, lakes, and reservoirs of the area. A USPHS report published in 1944 (*10*) indicated that almost nothing was known of the fauna and algal flora of the Potomac River, and this appears to be true for all of the rivers of the Chesapeake area. A number of papers refer to the algae found in public water supplies, however, and from these it is possible to obtain some idea of the most significant forms. The most common diatoms would appear to be *Asterionella, Cyclotella, Fragilaria, Melosira, Navicula, Nitzschia, Stephanodiscus, Synedra,* and *Tabellaria.* Common green algae would include *Actinastrum, Ankistrodesmus, Botryococcus, Closterium, Coelastrum, Pediastrum, Scenedesmus, Spirogyra, Staurastrum, Stigeoclonium, Tetraedron,* and *Ulothrix.* Among the common blue-green algae are the genera *Anabaena, Anacystis* (*Microcystis, Clathrocystis, Chroococcus*), *Aphanizomenon, Coelosphaerium, Cylindrospermum, Lyngbya, Oscillatoria, Phormidium,* and *Rivularia.* The more common algal flagellates would include *Ceratium, Chlamydomonas, Dinobryon, Eudorina, Euglena, Glenodinium, Mallomonas, Peridinium,* and *Trachelomonas.*

Visible and sometimes extensive algal blooms have been reported for both the streams and reservoirs of the Chesapeake area. Three extensive growths of the diatom *Synedra* were reported for the Potomac River between 1934 and 1938 (*11, 12*). The species represented were listed *S. delicatissima, S. pulchella,* and *S. ulna.* Plankton records at Washington, D.C., for 1954 (*3*) show that this genus reached bloom proportions in April of that year with a count of over 1,700 cells per milliliter. In a report for the same area, 25 years earlier (*13*), *Synedra* was recorded as so abundant that the organisms were placed into two categories with *Synedra* as one and all other organisms grouped together as the other. At Wilmington, Del., *Synedra* has been one of the predominant algae and in 1947 reached counts of 4,000–10,000 per milliliter (*14*).

Baltimore, Md., has reported that *Oscillatoria prolifica* and *Spirogyra* are usually present in great abundance (*15*). *Asterionella gracillima* has reached a count of 1,700 per milliliter in October. Other algae listed as common at Baltimore include *Anabaena flos-aquae, Aphanizomenon, Closterium, Botryococcus, Ankistrodesmus, Ulothrix,* and *Stigeoclonium.* At Washington in 1954 (*3*), algae in addition to *Synedra* with counts reaching 1,000 or more cells per milliliter were *Navicula, Cyclotella,* and *Chlamydomonas.*

Water polluted with city sewage has been reported as developing unusually prolific growths of algae. For example, complaints were received during the summer of 1928 regarding color and floating material in Back River in the vicinity of the Baltimore sewage treatment plant. Investigations indicated that algae were the probable immediate source of trouble. Extensive mats of green algae covered practically the entire surface of the stream (*16*). Also at Back River, *Chironomus* larvae, referred to as bloodworms, were the cause of an extremely bad nuisance during one summer (*17*). The water was covered with the sheaths of the hatched pupae, and the

minute flies were not held back by mosquito wire screens. *Chironomus* larvae have been reported in large numbers in a raw-water reservoir at Hyattsville, Md., during a period of low water (*18*). White worms, *Sagomyia plumicornis,* were also found in the raw water, but their invasion lasted only a few days.

According to Purdy (*19*), at the lower end of the upper Potomac, near Washington, diatoms were the most numerous of all the algae in the warm, as well as the cool, seasons. Genera which were dominant at different times of the year were *Nitzschia* in October, *Navicula* and *Synedra* in early November, *Pleurosigma* in late October, and *Synedra* again in March and April. In the lower Potomac, where pollution from city sewage was apparent, blue-green algae, green algae, and pigmented flagellates were often abundant and often outnumbered the diatoms.

In the process of evaluating a method of biological stream analysis for use as a sensitive indicator of pollution, Kaplovsky and Harmic (*20*) found the following algae to be common in Red Clay Creek in Delaware: *Oscillatoria, Rivularia, Meridion,* and *Tabellaria.* They concluded that a biological measure of stream conditions is a more sensitive indicator of pollution than the normal chemical and physical analyses employed and that it also can indicate previous pollution.

In Maryland, Bold (*9*) found that smaller ponds polluted with sewage produced visible brilliant green blooms. The algae present in abundance were the pigmented flagellates *Pandorina morum, Eudorina elegans, Chlamydobotrys stellata,* and *Pyramimonas montana.*

Thus, in the Chesapeake area, algae and other microscopic life are present in large numbers in those portions of streams that are polluted with domestic-sewage effluents, in small lakes or ponds accessible to stock, and in streams and other bodies of water which are bordered by rich agricultural lands, for example, in the piedmont plateau. High turbidity of stream water caused by silt tends to limit the algal growth, but the limiting factor is removed by impoundment, which allows suspended matter to settle out, and prolific algal growths then develop. The rivers probably have a high percentage of diatoms, particularly *Synedra,* while the lakes and reservoirs have a more cosmopolitan population of many types of algae.

One aquatic flowering plant, the European water chestnut or water nut, *Trapa natans,* has invaded the Chesapeake area. It was first seen in the Potomac River in 1923 and was eliminated only after an intensive 5-year program of underwater mowing. A new outbreak was reported in 1954 in the Gunpowder River in Maryland. In water 10 ft or less in depth, it forms dense mats that completely cover the water during the summer, and the water tends to become stagnant (*21, 22*).

Taste and Odor Problems

For the treatment plant operator, one of the most difficult problems is the effective control of tastes and odors in the water. In the Chesapeake area, as in many other parts of the country, the presence of algae is associated with many or most of the occurrences. Reservoirs and rivers are both able to support growths of taste and odor algae, but the reservoirs have a combination of factors that makes them more favorable for the development of these organisms.

Baltimore reported (*23*) that in one respect the Loch Raven Reservoir was a detriment, as it proved to be a splendid breeding place for microorganisms, with its large volume of clear water moving at a slow velocity, together with a large number of shallow areas around the margin. The algae which developed imparted a very objectionable taste and odor to the water. Another report on Baltimore (*24*) indicates that some of the fishy, algal, and other tastes were caused by the decomposition of the diatoms *Asterionella* and *Fragilaria*. When ammonia-chlorine treatment was used, the taste was removed in cold water except for a faint woody tang, but hot water had an annoying aromatic odor (*25*).

As a result of a rise of more than 50 ft in the level of Loch Raven Reservoir, the plankton count jumped from an average of less than 300 organisms per milliliter to almost 5,000 per milliliter (*26*). The organisms representing this great increase in numbers included several important taste and odor forms, such as the diatoms *Asterionella* and *Fragilaria*, the desmid *Staurastrum*, and the flagellate algae *Uroglenopsis*, *Dinobryon*, and *Peridinium*. One of the causes of the increased growth of algae in the reservoir was the reduced turbidity, which dropped from an average of approximately 85 ppm to 8.5 ppm after impoundment. The maximum turbidity dropped from more than 450 ppm to 11 ppm. Light exclusion is one of the most important effects of suspended matter on algae, for it interferes with their photosynthetic action, thus depriving them of active growth (*27*).

Baylis, reporting on the Baltimore supply (*15*), stated that when the ice broke up in the early spring the bacteria in the raw water were abundant, running as high as 500,000 per milliliter. The release of all this decayed matter usually produced bad tastes and odors. He stated that in a mild winter the decaying algal growths are not held in one place where the decay occurs but gradually diffuse throughout the water, so that concentrated, serious tastes and odors are prevented from occurring.

Other cities in Maryland, such as Aberdeen and Westernport, have reported serious taste and odor problems. In one city the exact cause and nature of the trouble were not determined but appeared to be associated with a well supply located in the industrial section of the town (*28*). The other community experienced colored water, as well as disagreeable odors, after water was obtained from an impounding reservoir formed by a dam on the Savage River (*29*). Investigations indicated that the color and odor were probably the result of decay of vegetation which had accumulated in the reservoir basin. It was believed that seasonal turnovers of the reservoir water might accentuate the problem and cause it to be particularly evident in the fall. At Laurel, Md., one of the troubles caused by algae was taste and odor production (*30*). The supply came from a spring-fed creek and was impounded in a small, open, raw-water reservoir with a maximum depth of only 6 ft. Algae and other organisms were described as thriving in the shallow reservoir. The intake pipe, being located at the lowest level, served the filter plant with the worst water in the reservoir, while the cleaner water went over the spillway. The alum used in treatment had about 4 per cent activated carbon mixed with it for taste and odor control.

In the vicinity of Claymont, Del., a carbon filter was installed to treat filtered water received from a treatment

plant in Pennsylvania, to eliminate some of the tastes in that particular water supply. Most of the supplies in Delaware are from wells, and the state experiences relatively few cases of tastes and odors due to organisms (*31*).

The Potomac and Anacostia rivers are both potentially capable of developing tastes and odors from algae. Organisms which are usually listed as taste and odor producers are said to be as common to rivers as to hard-water lakes and reservoirs (*10*). These include certain diatoms, olive-green flagellates, blue-green algae, yellow flagellates, green algae, green flagellates, and dinoflagellates. For example, Purdy (*19*) has listed for the Potomac River such taste and odor algae as *Eudorina, Staurastrum, Asterionella, Hydrodictyon, Anacystis* (as *Clathrocystis*), *Dinobryon, Fragilaria, Peridinium,* and *Ceratium.* These, however, tended to be common only below areas influenced by the presence of sewage effluents. *Peridinium* was recorded as reaching 90,000 per liter at one station on the lower Potomac.

Synedra, which has been considered an important taste and odor producer, is one of the most common organisms in the upper Potomac. A survey of the Potomac River in September 1936 showed the presence of large amounts of *Synedra* from Great Falls, Md., to just above Shepherdstown, W.Va. The greatest concentration was around Seneca, Md., a few miles above the District of Columbia, where the water was limpid and had a musty odor (*23*). At the same time *Synedra* was present in very large numbers at the Washington, D.C., plants, but the absence of odor complaints from users of the finished water indicated that the various methods of treatment at the city's Dalecarlia and McMillan plants apparently were successful in combating the odor.

It has been predicted that taste and odor occurrences in the Washington, D.C., raw-water supply may gradually increase. The causes for this were summarized (*10*) as follows: [1] increasing use of lands for agriculture in the Potomac watershed, with increasing fertilization of the surface runoff; [2] increasing watershed population; [3] increasing use of water, necessitating more use at the low-water stage; and [4] increased "algae consciousness" among water users.

Water obtained for the suburban Washington district from the Anacostia River formerly required frequent treatment with an algicide to prevent the development of tastes and odors. The turbidity of the river ranged from 10 to 10,000 ppm, and when high it was accompanied by strong tastes and odors (*33*). The large amount of silt would make it seem possible that actinomycetes with their prominent earthy odor might have been washed into the water from the surrounding soil to give the water its strong flavor. The odor in the water from the Anacostia River was described as a muddy, woody, river taste (*34*).

During the severe drought of 1930, some cities reported no unusual problems arising from algae or other aquatic organisms. Baltimore recorded no taste, color, or odor troubles directly traceable to the drought. Luke, Md., reported its raw-water supply, coming from the Potomac River, as having a color ranging from 2.0 to 8.0, presumably due to algae. Tastes and odors in the Washington water supply, but not in their home supply, were reported by persons residing in the suburban district and working in Washington. Officials pointed out, however, that the complainants at that time were re-

ceiving the same water in their homes as was supplied to their places of business in Washington. During the drought, the Washington suburban district had been forced to abandon its normal source of water and to obtain its entire supply from the Washington water department (*35*).

One community in Maryland during the 1930 drought had more than its usual share of odor and color due to algae and organic sludge. The coagulating basin became very foul and the odor of the water very offensive. The water was obtained from a surface stream whose watershed contained considerable areas of marshland and abundant vegetation. Part of the treatment during that period included treatment of the reservoir with 0.5 ppm copper sulfate (*35*).

The remains of minute red worms were reported to have set up a very strong taste and odor in the water of an open reservoir in the distribution system at Burnt Mills (*36*).

Filter Clogging

A second problem caused by aquatic organisms in water treatment plants is the reduction in the length of the filter runs by clogging of the sand filters.

Baltimore has reported that the crustacea *Cyclops* and *Daphnia* sometimes entered the treatment plant with the raw water in such numbers that they greatly shortened the filter runs, while other organisms reduced the effective area of the filters by adhering to the sand grains, causing them to stick together (*23*).

Impounded water, especially during the first year or so after construction of a dam, is likely to cause shorter filter runs owing to the increase in number of organisms. At Baltimore, the 2-year average number of plankton per milliliter before impoundment was 211, and the filter runs averaged 49.8 hr, with a maximum of 100 hr. In the first year after impoundment, the average plankton count was 4,724 per milliliter, and the average filter run was down to 25.5 hr, with a maximum of 37 hr (*26*).

In 1951, the filter runs at the treatment plant in Laurel, Md., were reported as being very short. Algae and other organisms thrived in the shallow reservoir, and large volumes of this material were drawn into the intake pipe. The water had only 50 min of detention in the sedimentation basin (*37*), and because of the inadequate settling, the filter runs were usually only 15 hr in winter and half that long in summer (*30*).

The "diatom epidemics" which occurred in the Potomac River are a convincing example of the importance of diatoms in the clogging of filters. The first epidemic occurred in September 1934, and the offender in this case was reported as *Synedra ulna* (*38*) and as *Synedra delicatissima* (*11*). Counts in the raw water ran as high as 2,000 cells per milliliter. At the Delacarlia treatment plant in Washington, D.C., the diatoms blocked the rapid sand filters so completely that it was necessary to wash them every 15 min. For the 6 years previous to this, no serious inroads of organisms had occurred to hamper filtration, and the river had given no evidence that any unusual conditions might arise (*32*). During the month of September 1934, however, the diatoms came suddenly and without warning.

Two years later, on the morning of Sep. 15, 1936, each of the rapid sand filter units at the Dalecarlia plant suddenly dropped, within an hour's time, from the normal 4-mil gal hourly rate

to 1 mil gal. Filter runs were reduced from an average of 50 hr to less than 1 hr. The offending diatom in 1936 was *Synedra delicatissima*, and counts reached as high as 4,800 cells per milliliter. During this same period the filter plant for Hagerstown, Md., about 60 air miles upstream, using water from the same river, experienced no difficulty and had a maximum of only 20 *Synedra* per milliliter (*32*). The 1936 epidemic at Washington lasted for a period of 20 days (*12*).

A third epidemic of diatoms reaching the Washington water supply occurred in July 1938. During the early part of the month there was no unusual evidence of organisms in the water (*11*). On Jul. 26, there appeared large quantities of a diatom reported as *Synedra pulchella*, but from its description as a number of cells fastened together like a comb, it probably was a species of *Fragilaria*. This diatom reached a maximum of about 1,700 cells per milliliter and was controlled with the use of large amounts of copper sulfate. The increased diatom production was ascribed to an increase in the amount of carbon dioxide in the water, which already contained a large amount of silica.

Baltimore also has recorded high counts of diatoms, especially in samples of water taken from the surface of Loch Raven Reservoir, but very little filter-clogging trouble was experienced. At Baltimore the water was drawn from a very deep reservoir and at a point that had been affected very little by the microorganisms (*39*).

An interesting account of a jellyfish in a sand filter was reported for the Washington treatment plant (*11*):

> Occasionally, rare forms of plankton appear without apparent cause or warning in the filter beds, only to disappear as quickly. In July 1927, when one of the filter beds was opened at Dalecarlia, thousands of tiny jellyfish, *Craspedacusta sowerbii* (Lankester), came crowding to the light from all directions. After 2 weeks all had disappeared. No jellyfish were found in any of the reservoirs. The filter beds were in total darkness, and there is very little circulation of air in them. At that time, their temperature varied from 81° to 75°F. During the time that the jellyfish were found in the filtration plant, the water 8 mi above this point was not being treated with alum, and their sudden disappearance coincided with the resumption of the alum treatment. Scrapings of the filter beds revealed no trace of the hydroid generation, and their sudden visitation remains a mystery to this day.

Other Effects

High pH readings for the raw water have been found to be associated frequently, with an increase in the numbers of algae. During the epidemic of *Synedra ulna* (or *S. delicatissima*) in the Potomac River, the pH rose to 8.8. The normal for this water was pH 7.8 (*38*). At the Loch Raven Reservoir near Baltimore, the pH changed from an average summer figure of 7.0 to 9.0 in a portion of the reservoir where diatoms were abundant. The pH was normal where protozoa were abundant and diatoms scarce (*39*). Hopkins stated that the pH would increase only if blue-green algae were present and would go down if protozoa were in abundance (*32*).

Microorganisms in the distribution systems have been reported a number of times. Open reservoirs for treated water have presented opportunities for algae to develop. Lauter compared an open and a covered filtered-water reservoir in the Washington system. Weekly microscopic examinations were

made, giving conclusive evidence in favor of the covered basins (*13*). *Synedra* was the organism present in greatest numbers in the open reservoir. Baltimore also reported heavy growths of algae in a small clear well and a large reservoir for filtered water, in spite of the fact that there was a high equivalent residual-chlorine content in both (*40*). Wilmington, Del., reported a dense growth of *Synedra* in the treated-water reservoir. This followed a spraying of the city from an airplane with DDT. In the 40-mil gal reservoir, the residual chlorine had been held to 0.2 ppm at the intake, but *Synedra* was present in large numbers 5 days after the spraying, and eventually reached a high of 10,000 per milliliter, with the color of the water rising to 15 ppm. Copper sulfate treatments were ineffective as a control while the DDT was present in the reservoir (*14*).

Some organisms appear to pass through the sand filters as eggs or as small immature forms and thus reach the distribution system. Various motile forms have been reported capable of passing through the sand. This is particularly true for protozoa and motile algae, as well as for some rotifers and crustacea (*15*). Both nematodes and red worms have been reported as present in sand filters, with a smaller number passing through into the distribution system. Seventeen species of nematodes were listed for slow sand filter beds at Washington, the four most common being *Ironus ijnavus, Ironus longicaudatus, Mononchus longicaudatus,* and *Tripyla monohystera* (*41*).

Red worms (*Chironomus*) were found in the raw water, on the filters, in filtered-water tanks, and in the distribution system during a severe drought period. They caused several complaints from consumers. Operators of the Burnt Mills plant of the Washington Suburban Sanitary District had no success in treatment with high doses of chlorine or copper sulfate (*18*).

Manganese is frequently reported to be present in water supplies of the area. Troubles caused by it in the finished water include staining of cloth articles during laundering and incrustation in pipes and filters. The manganese enters the water by being absorbed from the rocks and soil of freshly inundated areas (*42*). Digestion of organic material at the bottom of reservoirs has been considered the underlying cause, as water containing free carbon dioxide and lacking oxygen tends to dissolve hydrated manganous oxides (*43*). Studies have been conducted at Baltimore and Luke, Md., to determine the role of bacteria and of plankton in accelerating the process of digestion and in furnishing the organic matter through settling of dead microorganisms to the bottom (*44, 45*).

Prevention and Control

Prevention of the various problems caused by interference organisms has been given consideration throughout the Chesapeake area. The use of ground water rather than surface water by a large number of communities has relieved them of troubles due to algae and most of the other aquatic organisms (*46*).

For impounded waters, several procedures for control of organisms are in use. Soil stripping of the area to be inundated is considered as helpful but expensive. It reduces the organic content at the bottom of the reservoir and is thus a method of retarding the increase in the manganese content of the water (*15*). Deep reservoirs are pre-

ferred to shallow ones, as the intake can be located at a depth which misses both the plankton growth nearer the surface and the accumulation of organic sediment near the bottom (*39*). Even in shallow reservoirs, trouble is reduced by raising the intake above the bottom (*30*). There is also a great advantage to be gained in the elimination of coves and shallow areas around the margins of a reservoir (*15*).

Pretreatment of all or parts of a reservoir with low concentrations of copper sulfate at frequent intervals throughout the spring and summer is considered effective in controlling the algae through the year (*23, 47*). Regular and frequent microscopic analyses for plankton are recommended as furnishing information that will permit early treatment before the microorganisms reach the troublesome state (*13*). Comparative data on the number of plankton in several potential water supplies have been used as an aid in selecting the new supply (*48*). A number of open reservoirs for treated water have been reported for the Chesapeake area. In two locations where open and covered reservoirs were both available, comparative studies on the numbers of organisms present have been reported. Heckman refers to the presence of red worms in the open reservoir at Burnt Mills, Md., and their absence in the covered reservoir at Hyattsville (*36*). Lauter described the two types for Washington, D.C., and found conclusive evidence in favor of the covered basins. In the covered reservoir, there were only three occasions when organisms were noted, whereas organisms were present in the open basins at all times, with large increases, especially of *Synedra*, in the summer months (*13*). The expense involved is undoubtedly the reason why several communities have continued to use open rather than covered reservoirs for storage of their treated water.

Reduction in the quantity of nuisance organisms in the Potomac and other rivers will depend to a large degree upon a reduction in the supply of nitrates, phosphates, and other nutrients which enter the streams from treated-sewage effluents and the runoff from fertile farmlands (*49*). They are also produced in the stream during decomposition of untreated-sewage effluents and other organic wastes. The construction of interceptor sewers to carry sewage below the cities, such as has been suggested for Washington, D.C., will reduce the pollution in areas where it is desired to use the water for other purposes (*50*).

Treatments for interference organisms represent a very significant phase of the work at many of the water treatment plants in the Chesapeake area. As a result of attempts to treat water during the *Synedra* epidemics at Washington, D.C., it was concluded that coagulation by excessive dosages of alum did more than any other single agent in dealing with the problem. Other promising agents were found to be iron sulfate with lime and chlorine as well as alum and activated carbon. Microscopic examination of the iron-chlorine-lime treatment floc revealed more organisms caught in this floc than in any of the others (*32*).

Ample sedimentation was required along with the high coagulation treatment for effective removal of organisms. The sediment which collects in a coagulation basin as a sludge has been responsible for tastes and odors in the treated water. This can be stopped or prevented by more frequent removal of the sludge from the bottom of the basin (*35*). Prechlorination of the raw water has been reported as

preventing the accumulating deposits from becoming septic for a period of 1 month or more between seasonal cleaning schedules (*51*). Open reservoirs in the distribution system at Baltimore have also had to be cleaned to remove the heavy algal growths on the sides (*25*).

Covering of the treated-water reservoir with wire screening has been tried in attempts to prevent midge flies (*Chironomus*) from depositing eggs on the water, which later would give rise to worm-like larvae (*36*). Ordinary mosquito wire may not be fine enough to prevent the flies from entering (*17*).

Copper sulfate was reported as ineffective in controlling large numbers of the diatom *Synedra* at both Wilmington, Del. (*14*), and Washington, D.C. (*32*), where it was applied continuously at a concentration of 1 ppm (*38*). The copper sulfate was also reported as not killing all of the crustacea (*15*) and the fly larvae (*36*), even when used at a concentration of 10 ppm. It is indicated that the amount of copper sulfate which was applied for general control of algae at Cumberland (*52*), Hyattsville (*36*), and Laurel (*35*) was 0.35–0.5 ppm. A special apparatus for applying copper sulfate in the Back River at Baltimore was developed by Smith (*53*). It was designed for more even and rapid distribution of the crystals.

Prechlorination was referred to in brief reports as one method that has been used in attempting to kill algae (*47*) and midge larvae. A concentration of 10 ppm bleached the worms but did not kill them (*36*). Chlorination of open treated-water reservoirs has been practiced (*13, 40*), but occasionally algae develop in spite of it (*25*). Statements concerning its effect on tastes and odors indicate that when used alone it may reduce the production of odors from sludge in settling basins (*51*), but may give rise to new or modified odors in water containing plankton (*15*).

Combined chlorine and activated carbon have been used in attempts to control tastes and odors. The former resulted in an improved water but it was not entirely free from tastes and odors. Those of chlorophenol origin were prevented from forming, but the woody tang was still noticeable (*24, 25, 34, 40*). Activated carbon has been used in Delaware and Maryland. The small amount of published information available indicates that it was satisfactory in removing tastes and odors from water (*30, 31, 33*). One report stated that no complaints had been received since the use of activated carbon was started (*34*).

Conclusion

As the population within the Chesapeake area continues to increase, much greater demands will be made upon the water supplies. Additional ground water supplies presumably are limited, and some of those already in use have developed difficulties due to underground pollution and to the intrusion of salt water. Plans for additional impoundments on the Potomac and other surface waters in the piedmont plateau region are already being made. Two other sources which might be tapped in the future are the relatively pure water in the Appalachian Mountain region of western Maryland and, when economical methods of conversion into fresh water are developed, the water from the sea. Unless these last two sources could be used exclusively, algae and other interference organisms in local surface waters would continue to create problems in water sup-

plies in the Chesapeake area, and their significance will increase with the demand for more and larger use of those surface water supplies.

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Fire Hydrant Efficiency and Standards

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AN adequate water distribution system together with efficient and properly installed fire hydrants is indispensable in providing the fire protection necessary for a modern community. A strong water system with weak fire hydrants is subject to the neutralizing effect of the laws of hydraulics. The large capital outlay required for a modern water distribution system makes it imperative that the water supply engineer design fire hydrant installations to complement the design of the distribution system.

Historical Development

The modern fire hydrant, in spite of its apparent simplicity, is a relatively recent innovation. A review of the numerous factors responsible for its seemingly slow development will serve to illustrate the historical relationship between the development of the modern water distribution system and the design of fire hydrants capable of delivering effectively the quantities of water available.

Buckets, the earliest equipment used in fire fighting, were followed by primitive displacement type hand pumps or syringes which were developed in the 16th century. The basic inefficiency of bucket brigades and the limited range of the hand pumps and syringes led naturally to the development of water bombs, leather hoses, and improved pumping devices. Later refinements in the displacement pumps provided increased range with a continuous stream and a steady suction feed. Ultimately, the displacement pumps were discarded in favor of present centrifugal pumps which have greater efficiency and reliability.

Early fire-fighting equipment was handicapped seriously by the lack of an efficient method of distributing water in quantities adequate for public fire protection. Cisterns, barrels, water holes, streams, rivers, and canals proved ineffective as sources of supply. The earliest water distribution systems used canals or ditches and wooden pipes made from hollowed logs. The relatively low pressure available from these systems provided a meager water supply for fire-fighting equipment.

Early forms of fire hydrants on these primitive pipe systems presented many problems. Probably the most troublesome was the tendency of reciprocating pumping equipment to rupture the weak systems by the water hammer effect. Higher pressures and larger-capacity distribution systems opened the way to the development of the modern fire hydrant and efficient fire-fighting procedures. The obvious advantages of pressure systems installed on private property accelerated the

adoption of higher pressures in water distribution systems. Private fire insurance companies started financing fire brigades in the early 18th century and these brigades commenced to improve fire-fighting methods.

Early Hydrants

The first "fire hydrant" consisted of a wooden plug driven into a hole in a water main which had been formed from a hollow log. When the plug was withdrawn the water would flow into a street depression. This primitive device produced the term "fire plug." Sanitary hazards, the entrance of dirt into the mains, and the maintenance of street surfacing provided the incentives to develop a better fire plug.

The first significant improvement over the wooden plug followed the introduction of cast-iron pipe for distribution systems. Early cast-iron fire plugs consisted of a branch riser with a wooden plug inserted. Water flowed directly out onto the street, resulting in a considerable waste of water and a poor suction source for the fire pumps. Canvas cisterns were next used to reduce water loss and to provide a better sump for fire pumps. A standpipe with a tapered end connecting to the water main and a hose connection above ground proved more popular and efficient than the cisterns.

As cast-iron distribution systems became more common, higher water pressures were introduced. These higher pressures soon rendered all plug type hydrants obsolete.

In the United States, construction of public water systems began about 1650; fire fighting began as an activity of private insurance companies or volunteer groups. By the beginning of the 19th century, however, fire fighting was recognized as a necessary municipal function. American water utility practice initially included the use of wooden plugs in the water mains and later the use of wooden hydrants. Cisterns were also used extensively, being replaced later by fire hydrants. A "modern" type of hydrant, patented in Philadelphia as early as 1801, was probably the forerunner of all wet-barrel hydrants. The dry-barrel design followed a few years later.

Both wet- and dry-barrel hydrants initially had tapered bases for inserting into wooden mains. A logical improvement consisted in installing the hydrant riser permanently in fittings in the cast-iron mains. A large variety of both flush and riser type fire hydrants was soon in production. The dry-barrel riser type hydrant early established its desirability by its efficiency and adaptability to the frigid northern winter climates; the wet-barrel riser type hydrant established its popularity in the more temperate climates.

The United States led the world in the development of high-pressure water distribution systems. Concurrent with higher pressures and stronger mains came the development of fire hydrants of the riser type continually charged with water and operated by effective valves. Limitations in hydrant capacity and improvements in fire pumpers resulted in the design of hydrants with adequate laterals and risers and lower friction losses. Philadelphia led most American cities in hydrant development and, by 1865, over 3,000 dry-barrel hydrants were in use there.

Public fire protection in the city of Los Angeles began in a rather leisurely manner. Early brick and adobe construction was somewhat fire resistant and only the wooden or straw roofs were combustible. The first fire

alarms consisted of a fusillade of pistol shots to call the citizens to duty. Bucket brigades were established from the nearest ditch to the fire, with buckets passed briskly from hand to hand until the fire "exhausted itself."

An orderly fire hydrant plan was indicated in 1868 by a condition included in a 30-year lease of water system facilities to the Los Angeles City Water Company. This lease required that the company install a fire hydrant on one corner of each cross street and replace all wooden pipe with cast-iron mains within a year.

Volunteer fire companies were organized in 1872 and the rivalry between the various companies rushing to the fire soon assumed even greater importance than the fire itself. In 1902 the city of Los Angeles—which then had an area of 43 sq mi—acquired title to all properties of the Los Angeles City Water Co., including 535 fire hydrants and 325 mi of pipe. Today, Los Angeles encompasses 454 sq mi and has 35,500 fire hydrants and 5,800 mi of water mains.

NBFU Standards

The NBFU has had a profound influence on the improvement of fire-fighting methods in the United States. In 1904, when it began a study of the adequacy of water distribution systems, it soon became obvious that the survey of a large number of major water systems would preclude mathematical analyses. Two practical criteria were selected to evaluate the system: the pressure survey and the fire hydrant flow program. The pressure survey employs recording pressure gages installed at strategic locations in each local system. Abnormal pressure drops under peak demands indicate an existing or potential system deficiency. The hydrant flow program uses portable pitot gages which were developed to measure the actual flow of hydrants. By flowing a group of four to six hydrants, the actual capacity of the system can be determined and related to a standard 20-psi residual pressure.

Quantitative fire-flow requirements were established for all cities according to their population. These requirements are tabulated in a standard schedule (*1*) issued by the NBFU.

Currently, the NBFU grades a city or town on its water supply, fire department, fire alarm system, police department, fire prevention program, building department practices, and structural conditions. Each item is graded and improvements are recommended.

The water supply is studied and graded on such factors as reliability of source of supply and distribution systems, type of distribution system, size of mains in system, quality and condition of pipe, and quantities of water available.

Fire hydrants are evaluated on such factors as their distribution according to the value of the district, inspection techniques used, condition, size and type of installation, and valves on hydrant laterals. This type of study exerts a healthy influence toward the rehabilitation of deficient fire hydrants and the establishment of higher standards for the installation of new ones.

In its standard schedule, the NBFU has established the following standard for size and installation of hydrants:

> Hydrants shall be able to deliver 600 gpm with a friction loss of not more than 2.5 psi in the hydrant and a total loss of not more than 5 psi between the street main and the outlet; they shall have at least two 2.5-in. outlets and also a large pumper outlet where pumper service is

necessary. Where the fire department normally uses the large outlet, one of the 2.5-in. outlets may be omitted. Hydrants shall be of such design that when the barrel is broken off the hydrant will remain closed. Street connection shall be not less than 6 in. in diameter. Hose threads on outlets should preferably conform to National Standard dimensions. Flush hydrants are considered undesirable because of delay in getting into operation.

This standard is designed primarily for dry-barrel hydrants. For wet-barrel hydrants—as used primarily in the western part of the United States—some modification is justified. The section of the standard schedule specifying a pressure loss of not more than 2.5 psi in a hydrant flowing at a rate of 600 gpm is considered to be an excellent criterion for a well designed fire hydrant. The number and size of outlets, however, should be specified with consideration to the potential fire hazard, the quantitative demand, the type of fire apparatus in general use, and the fire-fighting methods used by the local fire department.

In Los Angeles, pumpers are dispatched to every fire. For this reason, provision for 2½-in. outlets for direct hydrant streams is not a vital consideration. In the congested high-value districts, duplex and triplex pumpers delivering 2,000 and 3,000 gpm, respectively, are in common use, as well as manifold wagons with sixteen hose outlets. In this type of area, the Los Angeles water system installs fire hydrants with two 4-in. outlets. In the less congested areas which require substantial fire flows, hydrants with one 2½-in. and one 4-in. outlet are specified. In residential areas with lower fire hazards, 2½-in. and 4-in. single-outlet hydrants are used, the size depending upon the pressure and strength of the distribution system. All laterals for new hydrants are 6 in. in diameter and include a 6-in. gate valve. When very high demands are expected from any one hydrant—or when an exceedingly long lateral is necessary—consideration is given to the installation of an 8-in. lateral.

AWWA Standards

The AWWA and the NEWWA jointly sponsored the first standards for fire hydrants. They were published as tentative in April 1937 and revised and published as a standard in August 1940.

A committee, with R. W. Esty as chairman, was appointed in 1944 to review and revise the 1940 standards. After considerable development work and review, the revised standards were approved by the AWWA and the NEWWA to become effective as a basis for all fire hydrant purchases made after Sep. 1, 1953.

These standards (*2*) contain a wealth of valuable data. For the purposes of this article, however, only those portions relating to hydraulic data will be considered. Although the standards are not applicable to the wet-barrel or "California" type hydrant, basic minimum hydraulic requirements should apply to all hydrants.

The following pertinent data are extracted from the 1954 standard:

5.2. *Size of Hydrant Valve.* The main valve opening shall be at least 4 in. in diameter for hydrants having two 2½-in. nozzles; at least 5 in. for hydrants having three 2½-in. nozzles; and at least 6 in. for hydrants having four 2½-in. nozzles. . . .

. . . as it is understood that hose nozzles and pumper nozzles are not in action at the same time, one pumper nozzle may

be added to any of the above hose nozzle combinations, or substituted for any one or two hose nozzles; provided that the discharge area of the pumper nozzle *either*: (a) does not exceed the discharge area of the 2½-in. hose nozzle or nozzles to which it is added or for which it is substituted, *or* (b) does not exceed the discharge area of the main valve of the hydrant. . . .

5.7. *Friction Losses.* With the hydrant 5 ft in length, measured from the bottom of the connecting pipe to the ground line, and discharging 250 gpm through each 2½-in. hose outlet, the friction loss shall not exceed the following:

Flow *gpm*	Pressure Loss *psi*
250	1
500	2
750	3
1000	4

It should be noted that the AWWA standard is based on the number of 2½-in. outlets, main-valve size, and friction losses in the hydrant. It should also be noted that friction losses are related empirically to flow in a linear relationship. Comparing the two standards on the basis of hydraulic formulas, the NBFU standard of 600 gpm at a pressure loss of 2.5 psi would be approximately equal to the AWWA standard for the same 2.5-psi friction loss.

Other Factors

Modern fire-fighting methods utilizing high-capacity pumpers create very high velocities in the standard 2½-in. outlet. These high velocities and the resulting excessive energy loss have rendered the 2½-in. outlet undesirable if not practically obsolete.

Inspection of the interior of hydrants in use for any appreciable time usually discloses tuberculation ranging from slight to extremely heavy. Study and experimentation is recommended to develop a vitreous or plastic coating for the interior of the hydrant barrel. This coating should maintain original high-flow coefficients over the life of the hydrant and minimize rehabilitation costs.

Recommendations

To relate the AWWA standards to those of the NBFU, it recommended that any future revision of the former include the following requirements:

1. All hydrants shall include at least one 4-in. outlet.
2. Friction loss in the hydrant shall not exceed 2.5 psi while delivering 600 gpm.
3. No fire hydrant barrel shall be of less than 6 in. ID for one 4-in. outlet or less than 8 in. ID for two 4-in. outlets.
4. The interior surfaces of the hydrant shall be coated with a material which will resist or eliminate tuberculation.

The adoption and utilization of these changes would improve the hydraulic capacity of new hydrant installations and provide an adequate supply of water for the modern improvements in fire-fighting equipment and fire-suppressive techniques.

Research Program

The need for data concerning the flow characteristics of fire hydrants became obvious in a study which was made to analyze deficiency points assessed against the Los Angeles water system by the NBFU. The department was particularly concerned with Item 31 of the NBFU standard grading schedule—Size and Installation of Hydrants.

It also became obvious that, if the flow characteristics of hydrants were known, the design engineers could more effectively select hydrants to utilize fully the strength of the distribution system. The justification for the research program becomes evident when one considers that about 1,000 hydrants are installed each year in the Los Angeles water system.

Flow Tests

A fire hydrant testing station was established between Upper and Lower Van Norman Lakes in the immediate vicinity of a trunk line. The facilities for testing hydrants consisted of a 12-in. header tapped to the trunk line with a 12-in. gate valve for throttling the flow to simulate system pressure fluctuations. A factory-calibrated 10-in. torrent type meter was installed sufficiently downstream from the trunk line connection to insure straight flow through the meter. The 12-in. header was continued beyond the meter and two 6-in. fire hydrant lateral connections were made—one, a typical short-lateral installation, 9.5 ft long; and the other, a long-lateral installation, 32.5 ft in length. In the lateral connection, 6-in. gates were installed at the 12-in. header. The short lateral installation was terminated in an open pit so that the fire hydrant elbow and riser section of the wet-barrel hydrants could be removed easily to install a dry-barrel hydrant. The hydrant elbow and riser section installed on the long lateral were buried because no dry-barrel hydrants were to be tested on the long lateral.

Pressure taps were made on the 12-in. header ahead of the meter and below the lateral connections. The tap downstream was used to record the residual pressure in the 12-in. header during flow. The pressure tap upstream was provided to aid in determining the throttling schedule of the 12-in. gate. Additional pressure taps were made on the 6-in. hydrant laterals at the hydrant elbow for the purpose of isolating the friction losses in the fire hydrant body and riser section from the remainder of the installation. Leads were installed from the pressure taps to the meter location so that all data could be recorded at one location. This also made it possible to set the pressure gages to be set at a common elevation, eliminating the need for corrections due to differences in elevations. Pressures were recorded by gages having a minimum pressure interval of 1 psi. The standard totalizing head on the torrent type meter was replaced with a sweep-hand test head calibrated for 100 cu ft per revolution.

A typical test was conducted as follows: The hydrant valve and the 6-in. lateral gate were opened, following which the 12-in. gate valve in the header was opened to predetermined positions. Approximately 6 settings of the gate valve were used to space the flows evenly between the maximum and minimum flows. For each setting, pressure gage readings of the residual pressure in the header and at the hydrant elbow were recorded. Flow quantities were determined by timing the indicator hand of the flow meter for one or two revolutions of the test head indicator. At least twelve runs were made on each hydrant from the closed-valve position through wide open and back to closed.

Several tests were made with stream shapers attached to the fire hydrant outlets to obtain a check on the metered flow by the use of a pitot tube

and gage. An excellent correlation of the flow data between the pitot tube and the calibrated meter was noted.

Hydrants Tested

Hydrants commonly in use in the Los Angeles distribution system were tested and their characteristic curves were plotted. This group consisted primarily of wet-barrel or California-type hydrants but included one dry-barrel type. Hydrants having the following designs and dimensions were tested:

1. A $2\frac{1}{2} \times 4$-in. angle valve on a built-up barrel, consisting of a 6-in. steel riser with a 6×4-in. tapered reducer
2. A 4×4-in. angle valve on a built-up barrel, consisting of a 6-in. steel riser with a 6×4-in. tapered reducer
3. Wet barrel with one $2\frac{1}{2}$-in. outlet
4. Wet barrel with one $2\frac{1}{2}$-in. and one 4-in. outlet
5. Wet barrel with two 4-in. outlets
6. Wet barrel with one 4-in. outlet
7. Dry barrel with one 4-in. and two $2\frac{1}{2}$-in. outlets

Flow Characteristics

The total energy available in the 12-in. header at the entrance to the lateral connection, in the 6-in. lateral at the hydrant elbow, and at the hydrant outlet were computed from the test data. The friction loss in the lateral and the friction loss in the riser and hydrant barrel were calculated by applying Bernoulli's equation.

A series of charts and graphs were prepared for use in the selection of hydrants to match distribution system characteristics. The curves (Fig. 1) show the relationship between the residual pressure in the main and the quantity of water discharged through the fire hydrant. It was recognized that the residual pressure in the main is approximately the total energy at the entrance to the hydrant lateral and that these curves were useful in balancing head loss in the distribution system against head loss in the fire hydrant installation.

Additional curves were prepared by plotting fire hydrant friction losses against the discharge quantity. These curves (Fig. 2) are used to compare hydrant efficiency with the NBFU requirements.

Adoption of 4-in. Outlet

The hydrant flow characteristic curves developed from the test data were compared with the NBFU standard of 600 gpm with 5-psi loss in the hydrant and lateral. The fact was obvious that hydrants with only a single $2\frac{1}{2}$-in. outlet would not meet the NBFU standard. The test results provided a strong incentive for the development of more efficient fire hydrants. It was reasoned that the continued use of hydrants with single $2\frac{1}{2}$-in. outlets was actually a waste of the energy available in the distribution system.

If the supply main is of adequate size, the velocity head in the main is very small—usually not more than 2 psi. Therefore, for all practical considerations, the residual pressure in the supply main is equivalent to the total energy available to create the velocity head in the discharge stream of the hydrant and to overcome the friction losses in the lateral and the hydrant. It naturally follows that a small outlet requires that a large percentage of the residual pressure be used

to create the discharge velocity in the outlet. By using a larger hydrant outlet, the velocity head needed at the outlet is smaller, resulting in a significant decrease in the required residual pressure. Consequently, if the required residual pressure is lower, a greater amount of energy is available to produce a larger flow in the distribution system.

Often, an increase in the flow from a hydrant can be accomplished simply by enlarging the hydrant outlet and without making any improvements to the distribution system. The solution lies in utilizing hydrants with a 4-in. outlet in lieu of a somewhat standard 2½-in. outlet.

Information from personnel of the Los Angeles Fire Department indicates that their modern fire-fighting techniques have rendered the 2½-in. hydrant outlet relatively obsolete. All responses to fires in Los Angeles utilize pumpers varying in capacity from 1,250 gpm to 3,000 gpm with suction hoses 4 in. in diameter or larger.

Experiments were conducted in the fabrication of built-up hydrants consisting of a 6-in. steel riser, standard pipe fittings, and a 4 × 4-in. angle valve. This hydrant was finally refined to include a screw flange, a 6-in. barrel with a 6 × 4-in. swaged reducer and a 4 × 4-in. angle valve. This was a relatively economical and

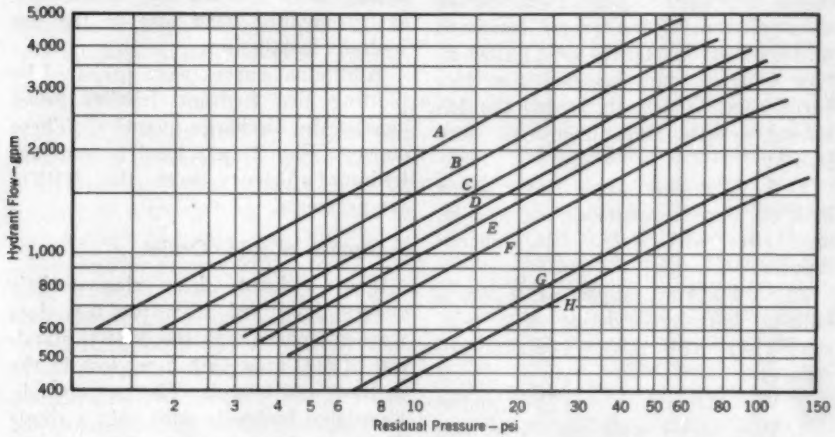

Fig. 1. Relation of Residual Pressure in Main and Free Discharge From Various Hydrants

Curves represent the following hydrant installations: A, *a double 4-in. wet barrel with both outlets open;* B, *a 2½- × 4-in. wet barrel with both outlets open;* C, *a double 4-in. wet barrel with one outlet open and a 2½- × 4-in. dry barrel with both outlets open;* D, *a 2½- × 4-in. dry barrel with a 4-in. outlet open;* E, *a single 4-in. wet barrel;* F, *a single 4-in. built-up barrel with a 4- × 4-in. angle valve open;* G, *a 2½- × 4-in. wet barrel with a 2½-in. outlet open and a single 2½-in. wet barrel; and* H, *a 2½- × 4-in. dry barrel with a 2½-in. outlet open and a single 2½-in. built-up barrel with a 2½- × 4-in. angle valve. Length of gated 6-in. diameter lateral is 9.5 ft for all curves.*

efficient hydrant and a limited construction program was initiated. The development of this particular hydrant inspired a hydrant manufacturing concern to design and produce a 4-in. single-outlet cast-iron hydrant with highly desirable flow characteristics.

capacity concept for pumper supply, is a more efficient facility for extracting maximum fire flow from a distribution system, and is a new tool for the water design engineer to utilize in special problems involving an adequate water supply for fire suppression.

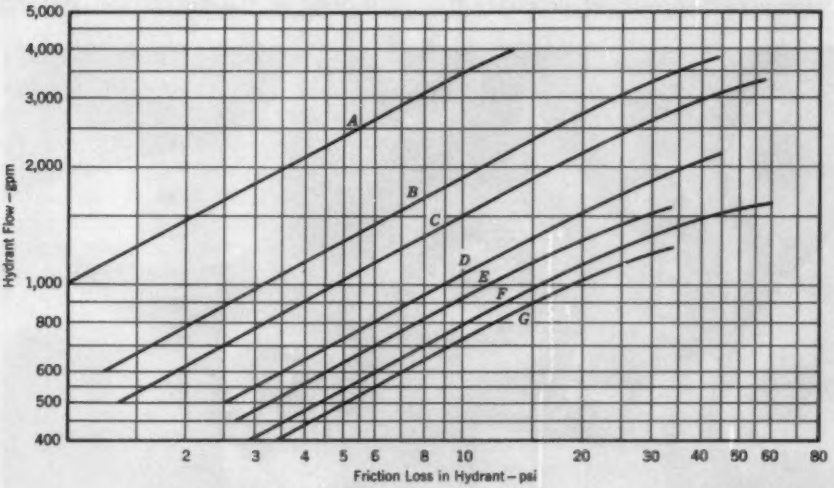

Fig. 2. Friction Loss in Hydrants for Various Rates of Flow

Curves represent hydrant installations as follows: A, *a double 4-in. wet barrel with one outlet open;* B, *a 2½- × 4-in. dry barrel with a 4-in. outlet open;* C, *a single 4-in. wet barrel;* D, *a single 4-in. built-up barrel with a 4- × 4-in. angle valve;* E, *a single 2½-in. wet barrel;* F, *a single 2½-in. built-up barrel with 2½- × 4-in. angle valve open; and* G, *a 2½- × 4-in. dry barrel with a 2½-in. outlet open.*

The 4-in. single-outlet fire hydrant has been adopted by the Los Angeles Fire Department as a basic hydrant for all residential areas where single hydrant capacity is adequate for the local fire risk. No new single 2½-in. hydrants will be stocked by the Los Angeles water system.

The adoption of the 4-in. single fire hydrant in Los Angeles is considered significant because it introduces a new

Design Standards

The design and installation of an adequate water system for a new residential, commercial, or industrial development seldom presents a problem. Performance standards expected by the NBFU can be incorporated in the design of a water system which will be installed prior to street improvements for an area development. One of the most perplexing water system prob-

lems occurs as a result of zone changes in old residential areas. Quite often single-family residential areas are rezoned as multiple-dwelling, commercial, and even heavy industrial zones. The existing distribution system probably will not meet the fire demands required by the revised land use. The large capital investment necessary for the wholesale replacement of entire networks places a heavy responsibility on the design engineer to effect the required increase in supply for fire protection at the lowest possible cost. Well chosen main replacements, short interior grid headers, rebuilding of deficient fire hydrant laterals, relocation of hydrants, and the installation of more efficient hydrants are all less expensive means of increasing the supply for fire protection from existing networks.

The design engineer must have accurate information concerning any system in which he intends to remove deficiencies. In the interest of economical design, it is vital to conduct hydrant flow tests in the distribution system.

Fig. 3. Hydrant Flow Test Being Conducted

Technique employs a pitot tube and pressure gage. Large assembly on hydrant is a stream shaper attachment for minimizing turbulence.

These tests can be made with any suitable hand pitot tube and bourdon pressure gage assembly. Fig. 3 illustrates the use of a pitot tube and gage and a stream shaper attachment used in a typical hydrant flow test. Experience has justified the use of stream shapers on the hydrant outlets to minimize turbulence in the streams and to insure accurate determination of the velocity

head. Equally necessary are strategically spaced pressure gages to determine system operation characteristics.

Examples of minimum system reconstruction and the resultant improvement in quantities of water available from the system are shown in Fig. 4 and Table 1. Those shown are actual instances of work performed in an older district of Los Angeles where the gridiron consists mostly of 4-in. and 6-in. mains installed in 1923. In all four examples, new hydrants with single 4-in. outlets were installed. Examples 2, 3, and 4 demonstrate the real possibilities inherent in minimum system reconstruction—such as combining more efficient hydrant installations with enlargement of the restrictive mains in the immediate vicinity.

Cooperation

In Los Angeles, cooperation between the fire department and the water department has proved to be of permanent value. The hydrant bureau of the fire department determines the location and approves the size of all new hydrants and advises on all matters relating to fire suppression activities. Fire-flow test results are reviewed jointly and remedial measures are agreed upon to assure maximum use of the available system capacity and the most economical system adjustments. All plans for system adjustments are reviewed by the hydrant bureau to determine if existing hydrants should be relocated or replaced with larger-capacity hydrants.

Hydrant Selection

The primary objective in installing a fire hydrant is to obtain a water supply adequate for the fire apparatus responding to the fire. The pressure in a distribution system is a reservoir of potential energy. This energy is dissipated in the pipe network, the hydrant lateral, the hydrant barrel, and lastly in the velocity head of the fire stream at the hydrant outlet. Any energy conserved in the lateral and hydrant is available to force more water from the pipe network to the hydrant stream.

Because determination of the proper hydrant for each installation is important, the following guides have been derived for application in the selection of hydrants for an existing system:

1. If the working pressure in an area is 100 psi or over and the pipe network is composed of 6-in. (or larger) pipe, 2½-in. outlet hydrants will deliver sufficient quantities of water for fire control in scattered, one-story, single-family residential districts.

2. If the working pressures are below 75 psi and there are considerable amounts of 4-in. or tuberculated 6-in. mains in the system, hydrants with outlets at least 4 in. in diameter should be used.

3. In a weak system or with lower pressures, significant improvement in flow can be obtained by installing the most efficient hydrant available to the local water system.

4. Where a large difference in ground elevation exists between hydrants on a small main, a large demand at the lower hydrant can result in low or even negative pressures at the higher hydrant. This effect can be minimized by installing, at the lower location, hydrants with high residual pressure characteristics.

These guides are of a general nature and must be subordinated to any local problems affecting system operation and fire demand.

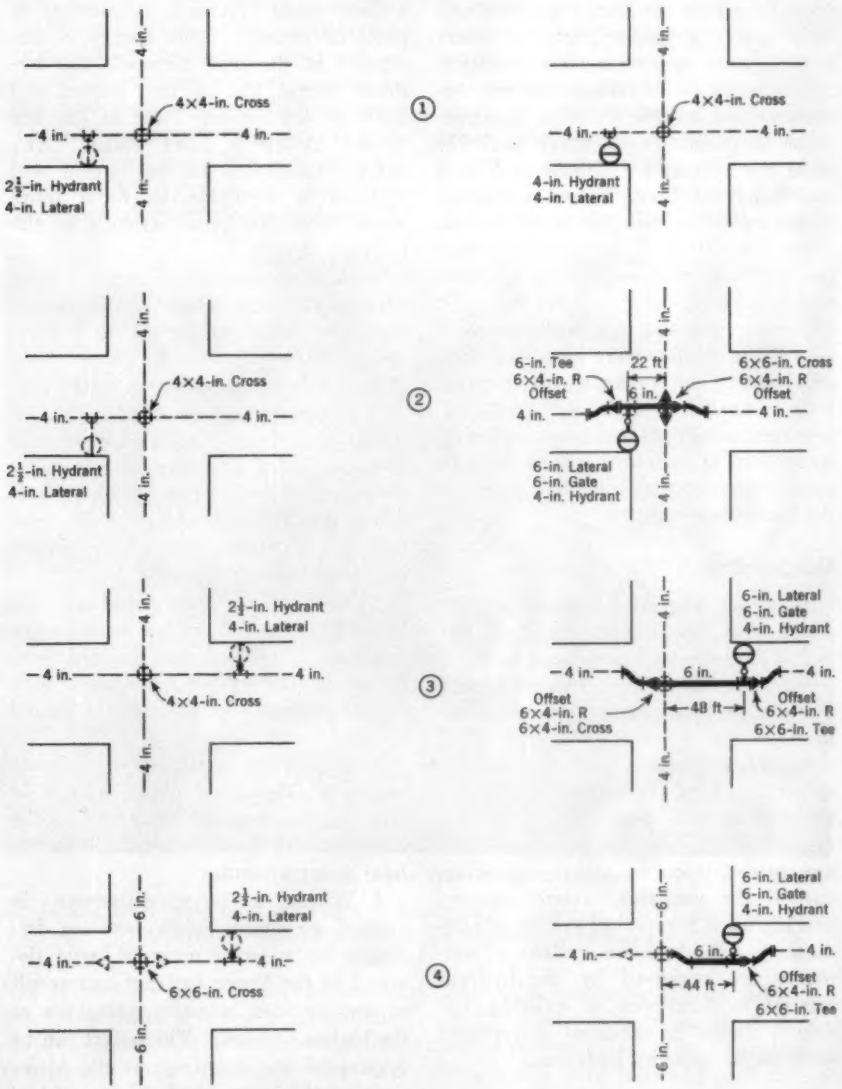

Fig. 4. Examples of Minimum System Reconstruction and Effects

Examples are of actual reconstruction made in section of Los Angeles system where gridiron consists largely of 4- and 6-in. mains installed in 1923. Diagrams at left are of installation before reconstruction; those at right, after reconstruction. Table 1, opposite, gives flow data of installations shown.

Conclusions

In an existing system, the quantitative requirements of the NBFU often can be fulfilled by the simple expedient of replacing obsolete or low-capacity hydrants with modern, efficient ones. In those areas where heavy pavement, traffic problems, and other factors make major pipe network replacement programs undesirable or impractical, system operating characteristics should be compared with the characteristics of various available hydrants so that the most effective hydrant can be selected to minimize reconstruction. A practical example of the improvement that can be obtained by a simple hydrant top change is illustrated by Fig. 4, Example 1.

In the event the gridiron has a high percentage of 4-in. and tuberculated 6-in. mains, an economical expedient can be used to increase greatly the delivery of water to a hydrant at the intersection of three or four mains. This consists of replacing a section of the main between the intersection and the fire hydrant lateral. If necessary, the lateral should be replaced and a more efficient hydrant body installed as illustrated in Fig. 4, Examples 2, 3, and 4.

In some areas, the water distribution system is plagued by low operating pressures and severe interior corrosion in the 4- and 6-in. network. In such situations, no economical short cut will provide adequate quantities of water for fire protection. The least costly solution is usually the installation of a supply main not less than 8 in. in diameter through the most deficient section of the system. Fire hydrants on deficient mains in the immediate vicinity of the main installation should be relocated to the new main. If these existing hydrants are deficient, they should be replaced with modern, low-loss hydrants.

Cooperation is an administrative practice which returns large dividends. This is particularly evident if a wholesome relationship is established between the personnel of the local water system and the fire department. Such cooperation can be achieved by joint conferences, training sessions, guest lectures, exchange of reports, and response to all major fires by trained water system personnel. Another effective method to encourage cooperation is that of having experts from the fire department meet regularly with water system design engineers and

TABLE 1

Data for Minimum Distribution System Improvements Shown in Fig. 4

Example	Before Improvement			After Improvement			Increase in Flow *per cent*
	Rate of flow *gpm*	Pressure—*psi*		Rate of flow *gpm*	Pressure—*psi*		
		Hydrant Closed	Hydrant Open		Hydrant Closed	Hydrant Open	
1	705	92	54	905	95	32	28
2	740	96	74	1,210	97	21	64
3	650	102	80	1,170	103	23	80
4	750	104	95	1,835	106	43	145

construction superintendents to review and discuss the solution to common problems. These conferences may cover such items as hydrant spacing and capacity, demonstrated deficiencies, and new fire-fighting equipment and techniques. The water system and fire departments of Los Angeles have attained close cooperation by application of the above suggestions. Such teamwork is recommended for water and fire departments of all sizes.

The final recommendation—simple but important—is that a hydrant design be adopted which includes at least one 4-in. outlet wherever fire department pumpers respond to all fires.

The water system design engineer should bear in mind that it is his responsibility to see that his water system is afforded every opportunity to deliver the water demanded for adequate fire protection in a modern community.

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Treatment Plant Innovations in St. Louis County, Mo.

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A paper presented on Feb. 6, 1958, at the Indiana Section Meeting, Indianapolis, Ind., by Herbert O. Hartung, Vice-Pres. & Production Mgr., St. Louis County Water Co., University City, Mo.

SOME of the treatment plant features of the St. Louis County Water Co. South County Plant (Fig. 1) may be innovations in the field. These features are:

1. A remote-operated river intake, consisting of submersible pumps, valves, and limit switches
2. A sloping, earth embankment purification basin, containing all treatment process units, including filtration
3. A suspended solids-contact lime softening unit, operated to obtain calcium carbonate near-stability by holding in suspension 50,000 ppm, or more, previously precipitated solids.
4. Flocculating drives which do not require a dry well
5. Distribution of coagulant and chlorine across the 100-ft wide treatment basin
6. A submerged filter within the treatment basin
7. A filter without clear well or rate-of-flow controller
8. Submerged, hydraulically operated butterfly filter valves and piping, which eliminate the need for the conventional pipe gallery
9. A pitot tube and pneumatic controller for filter wash water.

Even though these features may be characterized as innovations, originality was not a design criterion. Design selections were based on economic considerations, consistent with proper functioning and with the public health values necessary to water supply management. The design goal was a low-cost but efficient water treatment plant. Low plant cost was a very important design consideration because the initial use of the plant would be limited to summer daytime operation.

The South County Plant is a 15-mgd peak load plant, supplementing the capacity of the 36-mgd North County Plant and the 85-mgd Central County Plant. A few of the departures from conventional design were only permissible because of the standby relationship of the three plants. For example, the South County Plant can be taken from service at night for filter washing, and during the winter for maintenance.

Source and Treatment

The source of supply for the South County Plant is the Meramec River. Table 1 gives some characteristics of this source. Facilities provided for the treatment of this water are: [1] lime softening and stabilization with retained suspended softening solids, [2] coagulation-filtration, [3] free residual chlorination, and [4] taste and odor control with activated carbon. In addition, these treatment facilities allow for frequent variations in the chemical

and physical characteristics of the raw water, caused by local rainfall.

River Intake

The river intake site and the surrounding area are below flood levels. Maximum floodwater level is about 33 ft above average flow level, 42 ft above minimum flow level, and 17 ft above the top of the river bank. The intake is designed for operation during flood submergence as well as at minimum river flows, utilizing submersible motors and valves.

Four 5-mgd, 100-hp submersible pumps and motors are installed in a wet pit at the river's edge (Fig. 2). These are remote operated from the purification and pumping station, over a mile distant. Switch gear, remote-control relays, and solenoids are on a power pole platform above maximum high-water levels.

Cone valves on the discharge piping of each pump function for check, shut-off, and surge-protection service. Submersible limit switches on the cone valves are a part of the "Start" and "Stop" control circuits of the pump. Floating debris is kept from the pumps by screens at the entrance to the sump and on the pump bowls.

This installation functioned properly during three different flood periods in 1957 when the entire pump pit was under water.

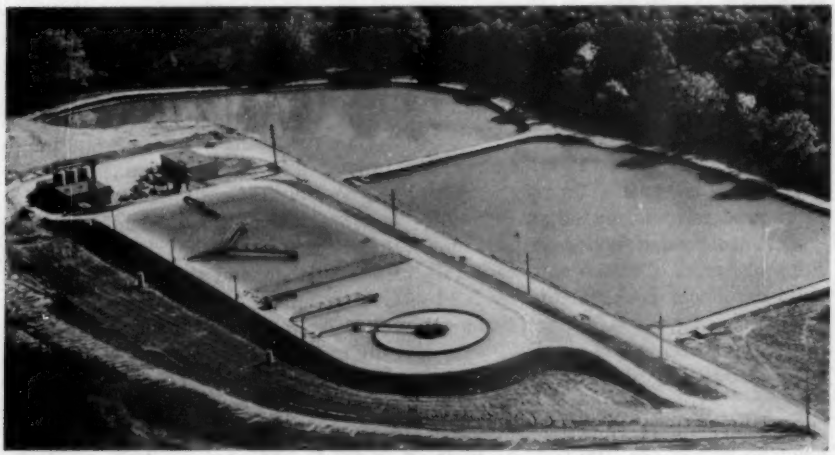

Fig 1. South County Treatment Plant

Sections of the water plant shown above include the softening and treatment basins in the foreground and the pumping and chemical house to the left rear.

Treatment Process

The treatment units are located and the treatment steps take place within a sloping, paved earth bank basin, 100 ft wide, 490 ft long (at the bottom), and 16 ft deep. This basin was built above normal ground with earth obtained from an adjacent borrow area. (The borrow area was subsequently used for waste water reclamation and

TABLE 1

Characteristics of Meramec River Water

Characteristic	Maximum	Minimum	Average
	ppm*		
Turbidity	2,000	6	150
Alkalinity†	0–200	0–30	0–150
Hardness	230	30	170
Calcium content	50	10	35
Magnesium content	35	1	20
pH	8.4	7.4	8.1

* Except pH.
† As $CaCO_3$.

softening sludge disposal ponds.) The plant was built aboveground, so that gravity drainage into the reclamation ponds could take place, and to permit the construction of a pump station only one story above ground, as well as for other reasons.

The basin contains, in order, from influent to effluent end: a suspended solids-contact softener, a primary collector, flocculation equipment, secondary collectors, and the filter. The entire basin must be drained to service any unit within the basin.

Several steps take place before water from the Meramec River reaches the filter of the treatment basin. The raw water enters the basin at the center of the softener. Softener-effluent water flows upward into the radial collection pipes and then horizontally into the primary settling zone. Chlorine and ferric sulfate coagulant are distributed across the basin as the water flows into the flocculation zone. After flocculation, the water flows across the secondary settling zone and then to the submerged filter. The high-service pumps are directly connected to the filter bottom, and the filter thus becomes the basin effluent system.

Solids-Contact Softener

The suspended solids-contact softener is contained in a lightweight cylindrical steel shell, 100 ft in diameter. Design detention time is more than 1 hr and the rise rate is about 1.5 gal/sq ft. The steel shell, which is not designed for unbalanced hydraulic heads, baffles the softening zone from the rest of the basin. The raw water is piped to the center of the softener where lime, raw water, and a large volume of previously precipitated solids are mixed by a power rotor in a center draft tube. Direction of flow in the softener is then vertically upward into radial collector pipes, which discharge the water horizontally into the clarifier zone.

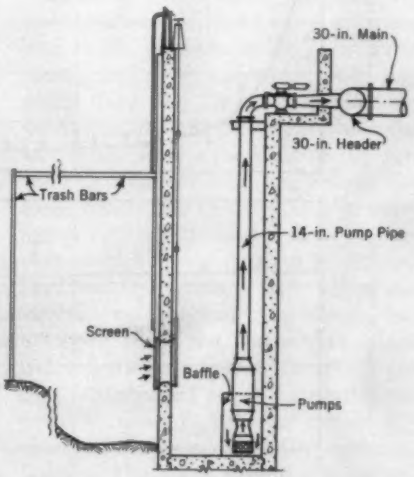

Fig. 2. River Intake Design

Four 5-mgd, 100-hp submersible pumps actuate the intake. Average water level is at 395 ft, with the average low-water level at 386 ft and the average high-water level at 405 ft. Maximum high-water level is 17 ft above the top of the concrete pump pit.

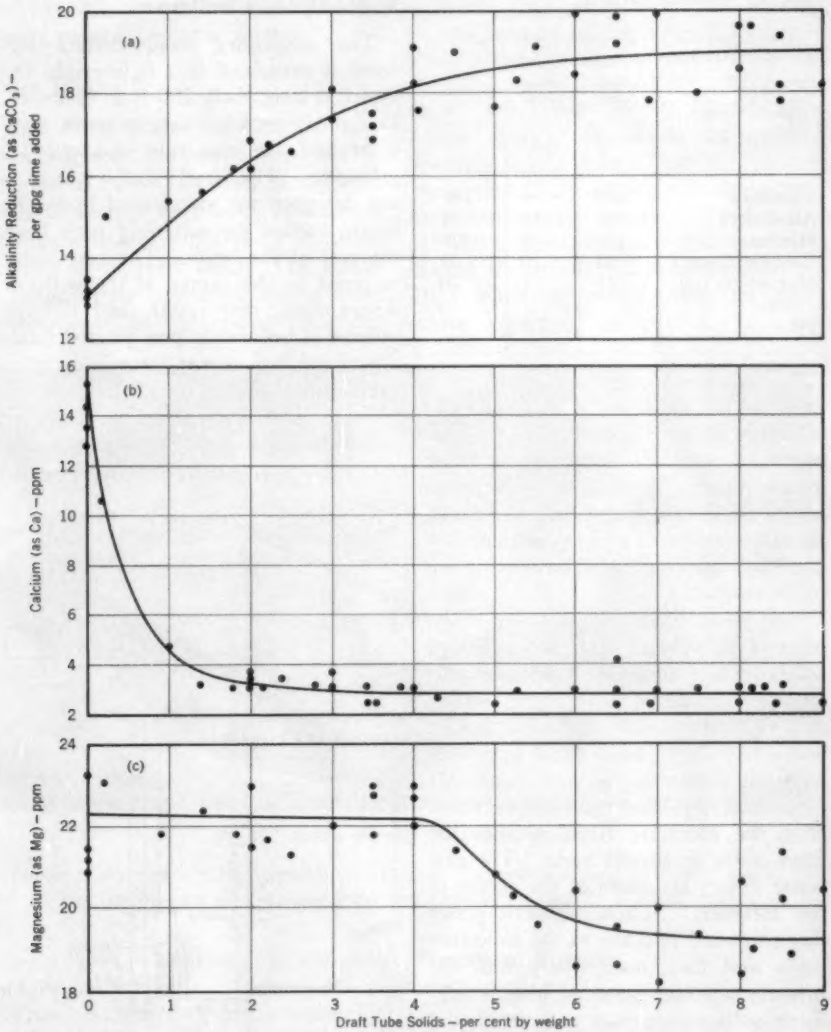

Fig. 3. Effects of Suspended Solids Concentrations

Curves denote the effect of solids concentrations on: alkalinity, Fig. 3a; residual calcium, Fig. 3b; and residual magnesium, Fig. 3c. Raw Meramec River water had an alkalinity of 175–185 ppm, calcium content of 40–44 ppm, and magnesium content of 24.5–26.5 ppm. Lime was applied at a rate of 6.2–6.4 gpg (106–110 ppm); the rise rate was 0.6 gpm/sq ft.

The function of the suspended solids-contact softener is to produce the maximum possible hardness reduction per unit of lime, and a maximum reduction in calcium carbonate and magnesium salts supersaturation. This is accomplished by softening in the presence of about 50,000 ppm or more previously precipitated hardness. The mode of operation is to accumulate and circulate the previously precipitated softening solids, and to add the raw water and lime into the circulating slurry.

The suspended solids-contact softener is not intended to produce a solids-free or low-turbidity effluent water. A slurry pool or sludge blanket level is not an operating objective. Slurry is allowed to accumulate in the unit and boil over the top into the following primary clarifier zone of the treatment basin. Clarification is by flocculation and secondary settling in the basin.

Suspended solids concentration in the center draft tube during normal operation has equaled 80,000 ppm for several days. Average concentration in the tube has been between 30,000 and 50,000 ppm. Softener operation in the presence of such large quantities of previously precipitated solids has resulted in softening which is appreciably greater than is possible when slurry is periodically or continuously withdrawn to maintain a slurry pool or sludge blanket level.

Tests were conducted to determine the effect of these concentrations on some of the constituents of Meramec River water.

1. *Effect on alkalinity.* The effect of increased concentration on hardness reduction per unit of lime is shown in Fig. 3a. The alkalinity reductions per unit of lime obtained in the softener are plotted against suspended solids concentration. An average curve drawn through the plotted points shows that in these instances, softening was increased about 45 per cent when the suspended solids concentration was increased from zero to 7 per cent by weight.

2. *Effect on calcium.* Residual calcium was reduced from 15 to 3 ppm (37 to 7 ppm as $CaCO_3$) by increasing the suspended solids concentration in the softener from zero to 7 per cent (see Fig. 3b). Most of this calcium precipitation was obtained when the concentration was more than 1½ to 2 per cent. The reduction of calcium alkalinity to 7 ppm approximates the lime softening quite often obtained with hot-process softeners.

3. *Effect on magnesium.* Magnesium as well as calcium hardness precipitation was increased when softening was in the presence of an appreciable concentration of suspended softening solids (see Fig. 3c). It should be noted that the lime treatment was equal to the alkalinity equivalent of the raw water. The residual magnesium for these waters was reduced from an average of 22.5 ppm to 19.5 ppm as magnesium, which was equivalent to 12 ppm hardness reduction. No important lowering of residual magnesium was obtained until the suspended solids concentration exceeded about 4½ per cent. Suspended solids concentrations equal to about 7½ per cent caused significantly increased magnesium precipitation. The total magnesium softening was then about 25 per cent of the magnesium hardness in the raw water.

These experiences seem to indicate that the amount of previously precipitated hardness which should be retained in the suspended solids-contact softener for the maximum softening efficiency is a function of the magne-

sium as well as the calcium softening to be obtained.

The separation of solids from the softened water is accomplished in the primary clarification zone of the basin which is immediately adjacent to and around the softener. Settling detention time at design flow is about 2 hr and the horizontal velocity is 0.87 ppm. The primary settling zone is equipped with a collector mechanism. The combination softener and primary collector zones of the treatment basin are considered to be the first stage of a two-stage softening and clarification plant.

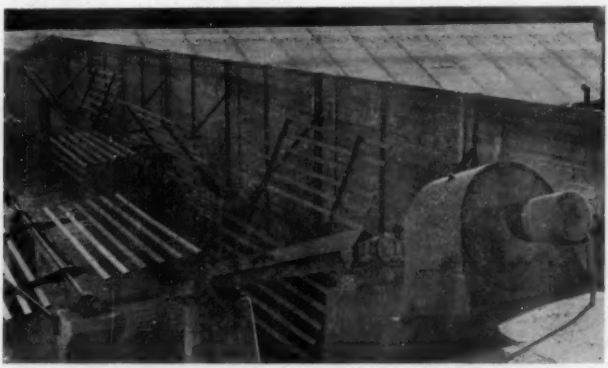

Fig. 4. Drive Shaft for Flocculation Equipment

Drive shaft is parallel to the sloping basin wall. A universal joint connects the drive shaft to horizontal flocculating shaft. Drive shafts of this type do not require a dry well.

Flocculation and Secondary Settling

Conventional 50-min transverse flocculation and 4-hr secondary settling are the second water-treatment stage, and are necessary to assure prefiltration water turbidity not in excess of 2–5 ppm. Wooden baffle walls separate the flocculation zone both from the primary and the secondary settling zones.

An important and cost-saving feature of flocculation equipment is its drives, which do not require a dry well (Fig. 4). Each row of flocculation equipment is connected directly to a motor-gear reducer by a solid shaft. The reducer is at the top of the sloping bank above the water level. The drive shaft parallels the sloping basin bank and connects to the horizontal flocculating shaft through a universal joint. This drive has been trouble-free to date.

Two-stage water treatment processing within one basin is made possible by a pumping arrangement which permits the uniform distribution of coagulant and chlorine solutions across the 100-ft width of the basin as the water flows into the flocculation zone (Fig. 5). The solution volume from the chlorinators is about 35 gpm, and from the coagulant feeder about 10 gpm. These rates are too small for uniform distribution across 100 ft of basin; therefore, these two chemical solutions are diluted into a 600-gpm water flow cir-

Fig. 5. Chemical Distribution Pump and Header

Pump makes possible uniform distribution of coagulant and chlorine solutions.

culated by a vertical low-head pump (the head is about 2–3 ft) hanging in the flocculation zone and discharging into an 8-in. pipe header, submerged and extending across the basin. Distribution of the pumped flow is through orifices on 2-ft centers in the pipe header. The coagulant pipeline and the chlorine solution pipeline from the chemical feeders terminate and discharge beneath and into the suction bell of the vertical pump. This method of applying chemicals to the basin flow eliminates the need for weirs, flumes, flash mixers, and basin inlet ports between the primary and secondary treatment stages of the treatment plant.

A number of studies have also shown the advantage of the slow, or stepped, addition of coagulant into the water. The dilution of the ferric sulfate solution and its multiple introduction to the water supply are also thought to be of value for this reason.

Filtering

A single, 15-mgd filter for backwashing, divided into two sections, is a part of the treatment basin (Fig. 6). The filter is located at the end of the secondary settling zone, and is completely submerged. The sand bed is 8 ft below the basin water level, and the filter box bottom is at the same elevation as the basin bottom. The filter is divided into two sections for backwashing. Each half of the filter is a reinforced concrete box, 36 × 50 ft. A wooden baffle wall is above the common wall of the two filter halves and functions only during filter backwashing.

The filter is the basin effluent system. Water flows from the secondary settling zone onto and through the filter, and out of the basin through the filter effluent piping.

The construction of the filter as a part of the basin instead of within a filter building has resulted in important cost savings. Important savings were also realized by the elimination of basin

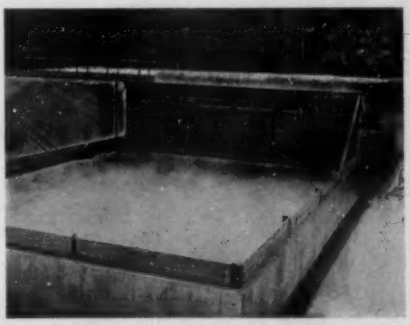

Fig. 6. Submerged Filter

Wooden baffle wall between the two halves of the filter functions during filter backwashing.

effluent and filter influent flumes and valves.

Filter wash water is stored in a 600,000-gal ground storage tank, located on a hillside above the plant. A 36-in. reinforced concrete pipeline connects the wash water storage to the filter bottom.

be functional, because the washing filter is about 8 ft below the water level.

During filter backwashing, clouds of unbroken floc, from the filter sand, gently move up into the basin. The rising wash water does not cause floc destruction, such as occurs when wash water spills into water wash troughs.

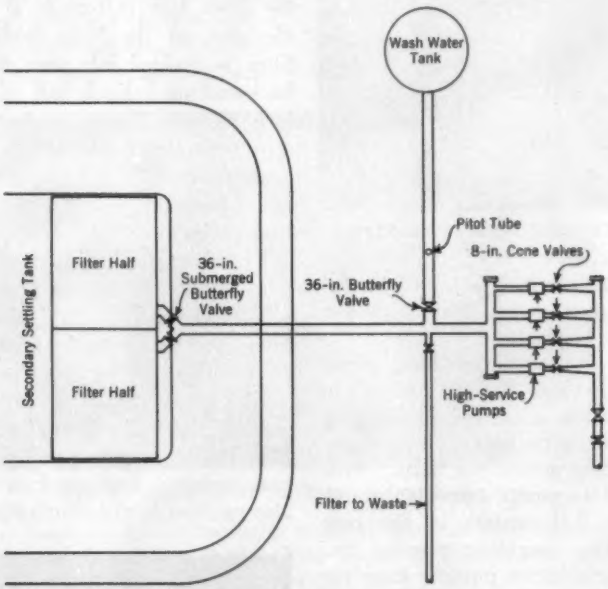

Fig. 7. Filter and Pump Piping

A 36-in. rubber-seated butterfly valve controls the wash water rate of flow and the flow shutoff.

Backwashing of the filter is at normal basin water level. During backwashing, the wash water fills the purification basin above normal water level and thus is automatically reclaimed. Filter sand expansion and wash water rise rate are the same as in conventional filter backwashing.

The filters do not have wash troughs or gullets. Wash troughs could not

After the wash water flow is stopped, the floc readily settles, leaving the supernatant water clear.

The quantity of wash water required per filter wash, and the duration of washing, are determined by the time required to remove the rising floc from over the filter sand into the basin settling zone. Complete removal of floc from over the filter is not necessary,

however, as the water above the filter remains readily filterable at all times.

Most of the floc from the washed filters settles in the secondary settling zone of the basin, but a small part of it resettles on the filter sand. Experience to date has been that a washed filter can be returned to service without a preliminary filter-to-waste operation, because the refiltered floc does not penetrate the sand bed.

During 1957, the wash water used by the South County Plant equaled 2½ per cent of the water filtered. Wash water requirements of the submerged filter exceed what is required for an equivalent conventional filter wash, because extra volumes of wash water are required to displace the water over the filter and to move the filter floc into the settling zone of the basin. Since all of the wash water is reclaimed without pumping, however, only the energy in the stored wash water is expended during filter washing. The cost of the additional wash water required for the submerged filter is only a fraction of the fixed charges on conventional filter and building construction.

Wash water rate of flow is controlled by means of a regulated 36-in. rubber-seated butterfly valve. This same valve is used for wash water flow shutoff (Fig. 7).

The primary element for flow measurement is a pitot tube, inserted into the 36-in. wash water line from the storage tank. The differential at the pitot tube is transmitted pneumatically to a pneumatic controller. The wash water butterfly valve is hydraulically positioned by means of a valve positioner, and is connected pneumatically to the controller.

The pitot tube, as a primary element for wash water measurement and control, is somewhat similar in cost to the orifice plate, but does not cause measurable loss of head.

Filter Piping

The high-service pumps are directly connected to the filter. The plant is without a clear well or filter rate-of-flow controller. The filter is equivalent to a strainer on the end of a pump-suction pipeline. Filtration rate is determined by the head characteristics of the high-service pumps in operation.

Direct pumping from the bottom of the filter, eliminating the customary filter rate-of-flow controller and clear well, has not been an operating disadvantage, nor has filtered water quality been adversely affected by the variations of high-service pumping. The elimination of the rate-of-flow controller results in a saving in pumping head as well as initial plant cost.

The filter effluent-pump suction piping is also, in part, the filter wash piping. This multiple use of the piping is possible because the plant is not required for service at night and can be shut down during filter washing. The 15-mgd filter thus only requires four valves: two filter effluent valves, a wash water line valve, and a filter-to-waste valve.

A further valve saving was made by eliminating the high-service pump suction valves, and by utilizing the pump discharge valves for check, slow opening and closing, and tight shutoff service.

The filter effluent valves are within the basin and are submerged. The valves are hydraulically operated and are the rubber-seated butterfly type

with submerged limit switches to indicate by remote operation fully open and closed positions. The four-way hydraulic valves for hydraulic piston operation are panel-mounted within the pump station.

Lime Delivery

The South County Plant is not near a railroad siding. Shipment of bulk lime to the plant is by truck transport, direct from the lime kilns at St. Genevieve, Mo., 80 mi away. The truck, which is specifically designed to handle lime, makes one round trip each day, carrying a 17-ton load. Two screws in the bottom of the trailer permit rear unloading directly into a bucket elevator; 17 tons of lime can be unloaded from the truck into storage by the truck driver in about ½ hr. The purchase of this transport truck made possible lime deliveries to the plant at railroad car prices.

Conclusion

The innovations described in this article, although well suited to the St. Louis County Water Co. South County Plant, in some instances have limited application in other treatment plant design. It is hoped, however, that this discussion will exemplify some cost-saving possibilities when the designer properly deviates from traditional design.

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Use of Coordinated Daily Laboratory Tests

Edward S. Hopkins

A paper presented on Oct. 31, 1957, at the Chesapeake Section Meeting, Washington, D.C., by Edward S. Hopkins, Cons. San. Engr., Baltimore, Md.

RECORDS of daily chemical and bacterial tests are utilized to determine the efficiency of filter plant operation, as a safeguard in maintaining health standards and for comparison of chlorination, coagulation, or softening dosages. Inclusion of the quantities of chemicals used in the treatment process is the basis for renewal of supply.

In 1930, a committee of AWWA published in the JOURNAL (*1*) a recommended form for reporting laboratory and plant operation data. This form is quite comprehensive in scope. The large filtration plants, with adequate laboratory staffs, have generally adopted it.

The sanitary engineering sections of the various state health departments have compiled similar forms. These monthly report forms are also very extensive. Their weekly forms, however, cover only what may be termed the basic criteria for successful plant operation.

Since these reports are summations of the daily log sheet developed by the individual plant operator to fit local needs, what information should be included in the log? The volume of water treated, average time of filter operation between backwashing, volume of wash water used, and temperature of the raw water comprise the physical characteristics. Chemical usage should be expressed as pounds per thousand or million gallons per day, with the average converted to grains per gallon.*

Dosages of chlorine, carbon, and hexametaphosphate are rarely less than 2 ppm or 0.12 gpg. If smaller quantities are applied, however, conversion to parts per million is justified to avoid use of very small decimals. In short, keeping the plant operation on a gallonage basis eliminates the involved calculations required for conversion to parts per million.

Analytical Data

Analytical results are another matter. They are reported in parts per million, because laboratory procedure is based upon the metric system. Conversion to grains per gallon is a definite ratio and can be applied when it is necessary to translate laboratory results into plant-operating data. Except to determine coagulation and sof-

* The editors disagree with the author's recommendation that average chemical usage be expressed in "grains per gallon." Although that unit may be a useful tool in plant operations, as the author notes later, its use in reports does not appear warranted. There the unit "parts per million," which has long been generally accepted in the terminology of the field, will permit comparison with data from other sources. "Parts per million" has the further advantage of being, for all practical purposes, equivalent (without the need of a conversion factor) to the unit "milligrams per liter," which is commonly used in chemical analysis.

tening chemical dosage, however, this rarely is required.

Pertinent analytical information should be noted on the daily log sheet, as follows:

1. For the coagulation of muddy or colored waters: turbidity, color, alkalinity, hardness, residual chlorine, and pH
2. For softening by the lime-soda process: alkalinity, hardness, residual chlorine, pH, bicarbonate, and carbonate

The procedure recommended by the AWWA committee (*1*) for bacterial reporting is satisfactory for entering on a log sheet, as it discloses the number of tubes tested and the number showing the presence of coliform organisms. It also provides for the presumptive and confirmed tests. The daily log sheet, however, must show the number of samples collected, particularly of the plant effluent. Bacterial sampling of the raw water, as it must always be considered as contami-

Title																				
Day	Pumping Data	Filter Operation	Chemicals Used	Analytical Data								Total Count Bacteria per ml					Coliform Organisms mpn			
				Turbidity			Color		Hardness											
				Raw	Settled	Filtered	Raw	Filtered	Raw	Filtered		Raw	Settled	Filtered	Plant Effluent		Raw	Settled	Filtered	Plant Effluent
1																				
2																				
3																				
4																				
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Total																				
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Average																				
Median																				
Geometric Mean																				

Fig. 1. Typical Monthly Report Sheet

Columns shown above are among those suggested by the author to record laboratory data.

3. For iron removal: iron, alkalinity, free carbon dioxide, residual chlorine, and pH
4. For manganese removal, the same information listed in Item 3
5. For corrosion control: iron, dissolved oxygen, alkalinity, calcium carbonate saturation index, and pH.

It is apparent, therefore, that the analytical data obtained should be selective and in accordance with the purification procedure utilized.

nated, with significant change in turbidity is justified, but with impounded waters comprehensive sampling is not necessary. The USPHS standards for certification are based upon bacterial testing from selected locations in the distribution system. Therefore, these samples become of importance and must be included in daily reporting.

Frequently, in the small water plant a choice must be made as to the types of samples to be bacterially tested

each day. Sampling of the plant effluent is most important, with selected taps from the distribution system of secondary importance. Although not a desirable practice, bacterial testing may be eliminated from impounded raw-water supplies assumed to be contaminated.

In making this recommendation, it is recognized that the bacteriological safety of water discharged into the distribution system is wholly dependent upon a sufficient concentration of free residual chlorine in the plant effluent. Therefore, it is obvious that the routine hourly free residual chlorine determinations are the criteria for plant control. Confirmation of this control is established by frequent testing for the presence of coliform organisms in the plant effluent.

When routine bacterial examinations are made as a part of a plant control program, by a local health department or other agency, these reports should be included in the monthly report.

While the 37°F count on agar is of value for comparative study, it need not be a routine procedure, because the purification standard is based on the density of the coliform organisms.

Analysis of the mineral content of the plant effluent is commonly performed in the large plant laboratories having adequate staff and facilities. It is useful in manufacturing processes, but, unless a large industry is located in the community, this analysis is not justified in the small plant. Frequently, this analysis is performed once a year by health departments, to make possible a comparison of the mineral characteristics of various water supplies.

Averages

Analytical data as usually reported in annual reports are so condensed as to be practically meaningless. Monthly averages of daily tests do not show the number of days that the constituent was above or below the average reported. This fallacy is not corrected by inclusion of the maximum- and minimum-day values. Inclusion of curves showing the daily variance of important constituents, rather than monthly averages, would be practical and preferable when comparative studies are made of plant performance.

The usual procedure of averaging daily tests is questionable. It has been demonstrated that the arithmetic mean (usual average) does not give a true picture of a series of analytical results when the single values are very unevenly dispersed (*2*). This is particularly true for coliform-organism density, iron alkalinity, and turbidity, which vary widely in raw water from a flashing stream. The density of the chemical constituents in the plant effluent are usually stabilized by the purification procedure and, if from an impounding reservoir, by storage. Under these conditions, the arithmetic mean usually provides a satisfactory median.

The simple average for widely varying constituents, when obtained from an array of daily tests as commonly used, is also not a representative value. The geometric mean, which may be obtained by averaging the logarithms of the values, provides a more representative figure. Its use for values varying over a wide range is recommended, as it would require only an added column on the monthly report sheet (Fig. 1).

Unless pertinent chemical tests are recorded each day, the information is frequently valueless for comparative study. In a flashing stream, the chemical composition changes rapidly, and the alkalinity, pH, iron, or hardness reported as the composite of all tests on Monday, Wednesday, or Fri-

day may be quite different from results noted on Tuesday or Thursday. This is also true after rainstorms with water taken from impounding reservoirs. When tests not taken in regular sequence are averaged by use of the arithmetic mean, they become even less accurate.

Example

Recently, it was of importance to learn the daily variance in iron, free carbon dioxide, alkalinity, and dissolved oxygen of a water under treatment in an iron removal plant. Because all constituents were not tested every day, a true picture of operating efficiency could not be obtained. Daily tests of all pertinent constituents would have disclosed possible idiosyncrasies noted elsewhere in the equipment used, but not apparent in the plant under study.

A corrosion study was made of a river. There are four treatment plants using this water. A review of the monthly reports, which were averages of daily tests, disclosed a uniformity in chemical constituents that did not correspond to streamflows. It became necessary to plot these data from daily tests at the four plants over a 5-year period to show fluctuating characteristics. Had this information been habitually reported on a daily curve in the annual report, since it was pertinent to the plant control, comparative information would have been easily noted and much work saved.

Summary

The daily log sheet should be developed to fit the local control tests required. There is no point in making unnecessary determinations just because they are listed on a "standard" report form.

The monthly report form is a compilation of the daily log sheets. It usually becomes a permanent record for use in studies of plant performance and efficiency of equipment. Frequently, the daily log is destroyed after the information on it has been transferred to the monthly report. Although this is common practice as an efficiency measure, historical data of great comparative value for plant control are occasionally lost.

The data found in annual reports are commonly monthly averages (arithmetic means) of daily determinations. These values do not reflect true operating conditions, even when maximum and minimum days are also reported to show the range of data covered. When the geometric mean is utilized for monthly reporting and supplemented by curves showing daily concentrations of selected chemical constituents and bacterial density, the annual report becomes a valuable comprehensive record of fluctuating plant performance.

Acknowledgments

Reviews and helpful comments by George L. Hall, Chief Engineer, Maryland State Department of Health, Carl J. Lauter, Dalecarlia Filtration Plant, Washington, D.C., and S. Everett Edwards, Superintendent, Ashburton Filtration Plant, Baltimore, Md., are appreciated.

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Municipal Watersheds in the Northeast

—Howard W. Lull—

A contribution to the Journal by Howard W. Lull, Chief, Div. of Watershed Management Research, Northeastern Forest Experiment Station, Upper Darby, Pa.

Part 1—Survey of Watershed Areas

IN the Northeast there are more than 300 municipalities that draw either part or all of their water supplies from forested watersheds or store water in reservoirs whose shorelines are protected by forest land. Some of these forest areas are owned by municipalities; some are owned by water companies; some are federal or state lands. They vary in size from the 35,000-acre Pequannock watershed of Newark, N.J., to areas of a few acres of planted conifers that screen a city reservoir.

To find out more about these watersheds, the Northeastern Forest Experiment Station of the US Forest Service recently sent letters of inquiry to officials of eleven states, asking information about location and size of municipal watersheds. Their replies, in the main, form the basis for the estimates given in Table 1 and elsewhere in this article. Some of these estimates are less exact than others; therefore, the author would be pleased to receive any information that is more detailed than that reported here.

Survey Results

In Connecticut, about two-thirds of the watersheds for municipal supply are owned by water companies. Of these, the New Haven Water Co. has the largest area, 21,000 acres; the Bridgeport Hydraulic Co. has about 17,000 acres. As to lands owned by cities and towns for water supply and reservoir sites, Hartford ranks first with about 20,000 acres; New Britain and Waterbury each have approximately 5,000 acres.

Delaware's sole entry in this table is the 280-acre reservoir property of the Wilmington Water Dept. In Maine, five of six areas range from 75 to 250 acres; Portland, the largest area, has approximately 1,600 acres.

In Maryland, over one-third of the municipal area is made up of the forested reservoir properties owned by Baltimore, about 18,000 acres. The Savage River State Forest makes up another third; it provides domestic and industrial water for Luke, Piedmont, and Westernport. Frederick has a watershed of 8,000 acres and Frostburg and Cumberland have forests of about 1,500 acres each.

In Massachusetts, the largest watershed forest, slightly more than 12,000 acres, is at Springfield. The Metropolitan District Commission of Boston owns 9,000 acres; and North Adams, Westfield, and Worcester have 6,000–7,000 acres each.

New Hampshire's largest area is Manchester, with 5,200 acres, followed by Gorham, with 4,700 acres. New Jersey's 48,000 acres in watershed forests was made up largely by New-

TABLE 1

Number and Area of Northeast Municipal Watersheds

State	Watersheds	
	No.	*acres*
Connecticut	58	103,835
Delaware	1	280
Maine	6	2,402
Maryland	8	48,821
Massachusetts	43	60,697
New Hampshire	25	19,720
New Jersey	7	48,030
New York	46	37,228
Pennsylvania	98	277,653
Rhode Island	3	13,020
Vermont	10	6,600
Totals	305	618,286

ark's 36,000-acre Pequannock watershed; Atlantic City has an area of more than 5,000 acres.

New York State reports a surprisingly low acreage considering its large area in state forest lands and its 672 community forests—the largest number in any one state. Table 1 includes areas of 7,000 acres for New York City and areas of 4,000–5,000 acres at Little Falls, Glens Falls, and Rochester. To this total area could well be added the watershed within the Catskill Forest Preserve along the Upper Delaware River that is tapped by New York City, perhaps 200,000 acres. Also, there is an unknown acreage of watershed land in the Adirondack Forest Preserve that supplies water to 20 municipalities.

About one-half of Pennsylvania's acreage in watershed forests consists of state lands that furnish water to 35 cities and towns. Almost 100,000 acres is owned by water companies, with the Scranton Gas and Water Co. and Spring Brook Water Co. possessing the largest area, approximately 24,000 acres. Lewisburg and Lewiston depend on the largest acreage of state lands, between 20,000 and 25,000 acres each.

Rhode Island's acreage consists largely of the 11,000-acre reservoir property of Providence. Vermont's watersheds include the 2,000-acre area of Rutland and the 1,000-acre area of Essex Junction and Montpelier.

To the total number of municipalities that own water supply or reservoir lands should be added an estimated 75 municipalities that secure their water supplies from an estimated 250,000 acres of national forest watersheds in the Northeast. Add to this the acreage comprising the source of New York City's water, and in round numbers the totals could be close to 400 municipalities and more than 1,000,000 acres of forest land. With respect to water supply sources and protection, this forest land is highly important to about one-third of the region's population.

Part 2—Problems of Forest and Water Management

For many years, managers of forest lands, serving either as sources of municipal water supplies or screens around reservoirs, operated under the belief that forest protection gives water protection. Fencing and patrolling to prevent trespass and fire protection were the essential tasks. The forest guarded the water supply, the water department guarded the forest, and, consequently, the job was simple.

Under such protection, the watershed forests and the plantations encircling reservoirs grew in volume and increased in value as they protected an increasingly valuable water re-

source. By the 1930's plantations established on reservoir shorelines in the early part of this century were producing salable products; second-growth forest watersheds, purchased originally for protection, had been inventoried, and management plans were common.

Ten years later, pioneering research at the US Forest Service's Coweeta Hydrologic Laboratory in western North Carolina was demonstrating that a forest that guarded water also consumed a lot of the water it guarded. Research indicated that forest cutting could increase water yield.

These developments have increased the responsibilities of municipal watershed managers. Entrusted with protecting water supplies, they also wanted the income from forest growth. Little guidance has been available to them; for, although many municipalities in the Northeast own forest watershed and reservoir properties, there has been no effort to pool experiences for the management of them.

Management Plans

Several municipalities have had forest-management plans prepared for their watershed and reservoir properties and have been getting an income from them. One of the best known, the Eli Whitney Forest belonging to the water company of New Haven, Conn., was for many years under the profitable management of R. C. Hawley of the Yale School of Forestry.

The Baltimore, Md., reservoir properties of 18,000 acres are being carefully managed by Louis Ningard, superintendent of watersheds. Here, under the direction of Walter C. Sushko, overmature and defective trees are being removed; undesirable species are cut where possible; and, generally, a minimum reserve of 3,000 fbm per acre is left.

The water bureau of the Metropolitan District of Hartford, Conn., employs Irving A. Hart to manage over 20,000 acres of woodland properties. John M. Heilman, another professional forester, directs the forest operation on the 35,000-acre Pequannock watershed of Newark, N.J. The American Water Works Service Co., Inc., of Philadelphia, employs a forester, James F. Heagy, to supervise harvesting operations on municipal watersheds.

Manchester, N.H., has a watershed forest that brings in a substantial annual income. In New York State, Glens Falls and Little Falls maintain productive watersheds. Westfield, Mass., has watershed plantations established in 1909, and Rutland, Vt., has an extensive reforestation program, dating from 1917, on 4,000 acres. These are but a few of many examples of forest management on municipal watersheds.

Forest cutting on reservoir and watershed areas must be carefully done to maintain the protective functions of the forest. This means keeping road areas to a minimum and locating and constructing roads so as to keep silt out of the water. Logging-road standards to protect stream flow from sedimentation have been developed by the US Forest Service from watershed research in West Virginia, New Hampshire, and elsewhere.

Research

Little information is available about the effects of ordinary cutting practices on water yield, although research under way at the US Forest Service's Fernow Experimental Forest in West Virginia should provide some interesting leads. In these studies, four small forested watersheds are being cut over in four different ways, ranging from

a commercial clear-cutting (where about 95 per cent of the volume will be removed) to an intensive selection cutting (where only 30–40 per cent of the volume will be removed). One watershed will be kept untreated as the control.

Researchers will determine how the different types of cutting and the road locations and drainage will affect water yield and quality. Cutting was started after 6 years of careful stream gaging to determine the relationships before treatment between watersheds, with respect to water yield, peak flows, and low flows.

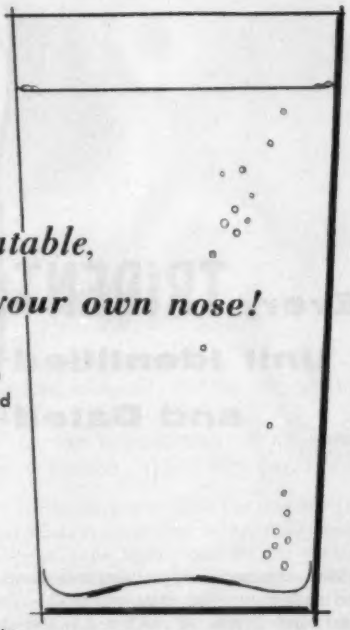
Studies of this kind may show the feasibility of increasing water yield through cutting practices—a worthwhile objective for municipalities that have reservoir space to store additional supplies. Basis for this possibility is the fact that approximately one-third to one-half of the annual precipitation received in the Northeast is used by vegetation in the evapotranspiration process.

Cutting part of the vegetation will by no means guarantee a proportionate increase in water yield. If transpiration could be reduced, however, less moisture would be removed from the the soil, so that less precipitation would go into soil moisture storage and more would be available either for stream flow or for ground water recharge. Annual increases of 5–10 in. might possibly be expected from a heavy cutting. Of course, sufficient ground cover should be left to prevent soil erosion and sedimentation. The greater part of this increase might be expected in the summer, the season when greater evapotranspiration takes place. Five inches of water saved per acre is equivalent to 135,770 gal, which at the faucet is worth perhaps $10.

In addition to normal soil moisture losses, the protective forest screen that borders many reservoirs sends its roots into the water table and can remove large quantities of water. The amount is unknown, but there is reason to ask if other types of vegetation might not be less costly in terms of water use.

Considerable research will be needed to answer these questions. Some is underway now by the US Forest Service at the Fernow Experimental Forest in West Virginia, the Delaware-Lehigh and Pocono Experimental Forests in Pennsylvania, and the Hubbard Brook Experimental Forest in the White Mountains of New Hampshire. At each of these forests, stream flow from forested watersheds is being gaged, climatic records are being obtained and fundamental studies of the interrelationships between forest cover, soil moisture, snow accumulation and melt, and stream flow are being pursued.

Recent interest in this field of study has led to development of two cooperative watershed research projects. In one, the Baltimore, Md., Bureau of Water Supply, the Maryland Department of Forests and Parks, and the Northeastern Forest Experiment Station will conduct watershed studies on the Baltimore reservoir lands. In the other, the School of Forestry of Pennsylvania State University, the Pennsylvania Department of Forests and Waters, and the Northeastern Forest Experiment Station will conduct studies on state and school forest lands near University Park, Pa.



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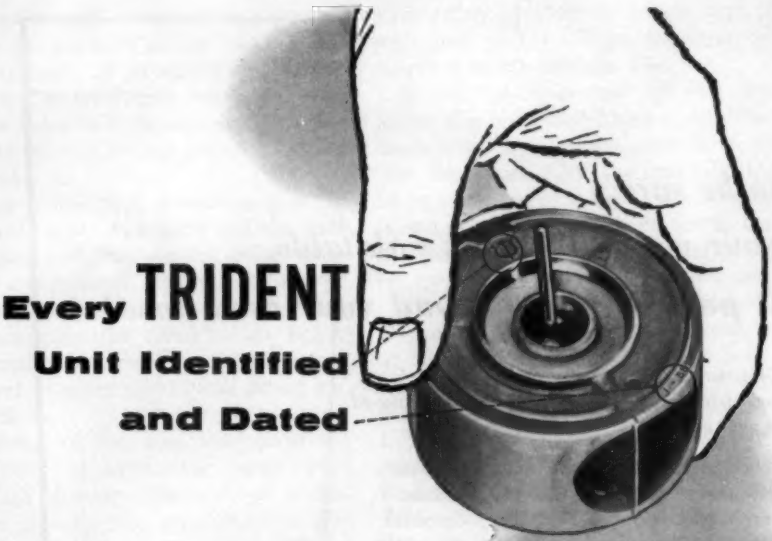

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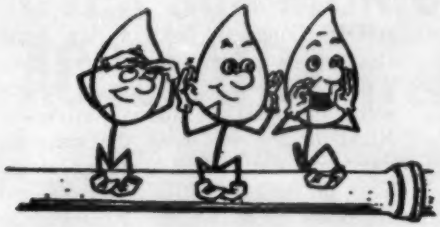

Percolation and Runoff

A golden anniversary in the celebration of which we certainly want to join is that of the Water & Sewage Works Manufacturers Assn. Founded on May 16, 1908, at AWWA's 28th annual convention in Assembly Hall, Washington, D.C., WSWMA has in the past 50 years grown into an efficient and effective organization whose cooperation with AWWA and FSIWA has been of major importance in the success of those associations, as well as of the industries which they represent. The object of WSWMA, as spelled out in its first constitution, was: "the advancement of the interests of its members and of the water works associations, the providing for exhibits of materials, the establishment of friendly cooperation and relations with its members and with the delegates of the water works associations." As far as the advancement of the interests of AWWA, the provision of exhibits at AWWA meetings, and the establishment of friendly cooperation and relations with AWWA are concerned, we can vouch for its eminent success. The day-by-day, problem-by-problem cooperation we receive from WSWMA certainly merits application of the slogan "Partners in Service"—not only to the industry, but to the public as well.

In the introduction to its anniversary booklet, WSWMA notes:

> In the 50 years since the manufacturers association came into being, enormous advances have been made in the treatment of water supplies and liquid wastes. In spite of a normally indifferent public and tight purse-strings on municipal budgets, water and sewage men have continually searched for more effective methods to provide the American people with abundant supplies of pure water and to return the waste products of our society to receiving rivers and oceans in a safe, innocuous form.
>
> In this search for improved techniques, the members of the Water and Sewage Works Manufacturers Association have played a vital role. Probably in no other segment of American business does a relationship exist between suppliers and users as that which occurs in our industry. In a very unique way, consulting engineers, water and sewage works men, and manufacturers and suppliers have cooperated to the fullest extent to provide the public with the most advanced system of municipal hygiene in existence anywhere in the world.

Not only has WSWMA been a notable participant in these achievements, but, within the past 5 years, it has

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(*Continued from page 35 P&R*)

undertaken to extend its cooperation beyond the traditional limits of its operations by accepting the responsibility for helping water and sewage works men to overcome the problem of "a normally indifferent public and tight purse-strings on municipal budgets." To this end it has sponsored a public relations effort which has been expressed through the means of the Water Resources Council, a group in which AWWA and some organizations interested primarily in "clean streams" have attacked one phase of the water problem. And, both through their association and individually, WSWMA members have given unlimited support to AWWA's "Operation Water Works Advancement" that is now undertaking the same basic job.

In AWWA's other new venture, too —the product certification program just getting under way—there is clear evidence of the partnership that has been of such benefit to both the industry and the public. Just as the support of WSWMA and its members has been vital to the acceptance of AWWA standards in the past, its cooperation in the initiation and development of certification will undoubtedly measure the success of that important program.

In 50 years WSWMA and AWWA have learned to work together well, to respect each other's prerogatives, and even to disagree amiably. We wish WSWMA a happy new half-century and look forward to licking with them our combined weight in space-age water problems.

AIDIS—the Inter-American Assn. of Sanitary Engineering—was the object of AWWA's special attention last May 18–24 on the occasion of the Sixth AIDIS Congress, held in San Juan, Puerto Rico; and at the same time AWWA and water, itself, were the objects of AIDIS' special attention. Right in the midst of the congress meeting place, AWWA set up an exhibit of its publications, and invited engineers from all the Americas to avail themselves of the latest in water works information. Meanwhile, AWWA's secretary was feted throughout the week as the congress' guest of honor, and all through the week, too, speakers at the technical sessions, from Assistant Surgeon General Mark Hollis to Sergio Cuevas, first president of the Puerto Rico Sewer & Aqueduct Authority, were pointing to water as the most important health measure for all the Americas and the key to a higher standard of living. Thus, the 500 engineers on hand to represent every country of the Americas were reminded and rereminded that the provision of good public water supplies constituted their most important problem.

If water was the most important subject of the week, it was not the favorite drink, for Puerto Rico is a land of rum. And a social program that kept everyone busy both afternoon and evening with parties, luncheons, tours, inspections, and even a special AIDIS trophy horse race at the El Comandante track provided ample opportunity for fortification against the heat and humidity. Governor Munoz-Marin entertained the group at La Fortaleza. San Juan Mayoress Felisa Rincon de Gautier, of *What's My Line?* fame, in addition to other appearances, was hostess to the group at a party in City Hall. Hosts all week were Rafael V. Urrutia, president of both AIDIS and the Sewer &

(*Continued on page 38 P&R*)

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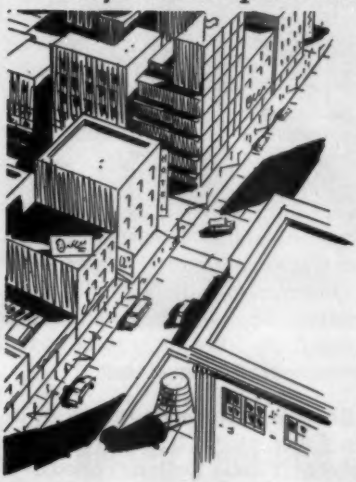

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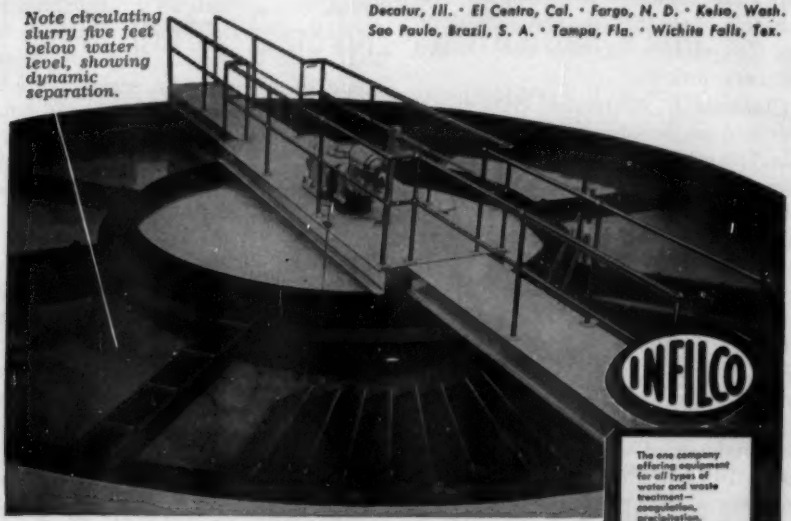
Note circulating slurry five feet below water level, showing dynamic separation.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(Continued from page 36 P&R)

Aqueduct Authority; Enrique Ortega, General Secretary of AIDIS and another member of the authority staff; and Thomas L. Brown, export manager of Permutit Co., who handled the exhibit arrangements for the meeting and was nominated as next AIDIS president.

It was a week during which the "American" in AWWA took on a much fuller meaning, and if the language sometimes provided difficulty, everyone pronounced *agua*, AWWA!

Canadian—Anderson

Manufacturer—Roberts

Two new directors have officially joined the AWWA Board since the Dallas Conference. The Canadian Section, at its meeting last month, elected Clarence S. Anderson to succeed C. G. R. Armstrong, whose term had expired. And WSWMA has chosen Charles V. Roberts to replace R. S. Rankin, owing to the latter's retirement. Mr. Roberts will complete Mr. Rankin's term, which ends in 1959. The biographies of the new Board members follow:

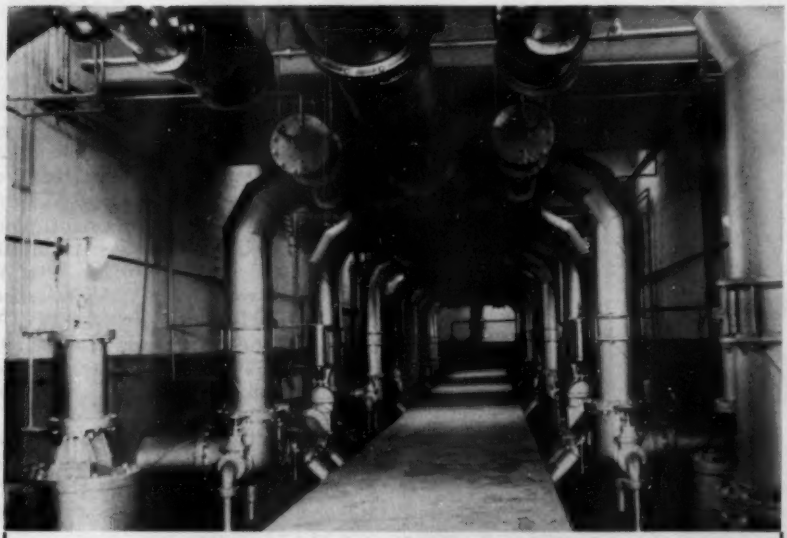
¶ **Clarence S. Anderson,** clerk-treasurer and commissioner of works, Tisdale Township, South Porcupine, Ont. Born and raised in Westmeath Township, Renfrew County, he received his public and high school education there. In 1926 he started to work on hydro developments, holding responsible supervisory positions on a number of projects. In 1933 he accepted employment with a gold mine in northern Quebec. He came to Tisdale Township in 1936 and has continued as commissioner of works to the present. Since 1951 he has also been clerk-treasurer of the township.

An AWWA member since 1938, he served the Canadian Section as chairman in 1955. He also belongs to American Public Works Assn., Canadian Institute on Sewage & Sanitation (president), City Engineers Assn. of Ontario, Institute of Public Administration for Canada, Ontario Good Roads Assn. (director), and Porcupine Institute of Administration.

¶ **Charles V. Roberts,** President, Roberts Filter Mfg. Co., Darby, Pa., and Roberts Filter Co. of Canada, Toronto, Ont. Born in Philadelphia in 1909, he was graduated with a B.S. in 1932 from Ursinus College, on whose board of directors he serves. He is also on the board of a number of business and civic organizations, has been an AWWA member since 1946, and has served two terms on the board of governors of WSWMA.

Something—perhaps the importance of water supply or perhaps the mobility of modern combat units—was proved conclusively early this year when a 200-ton, 197-ft-high elevated steel water tank 60 ft wide at the base was loaded on 12 dollies and moved 9 miles to a new location at Edwards Air Force Base in California. Or could the tank originally have been in a general's backyard? At any rate, herein lies a new public relations possibility.

(Continued on page 40 P&R)



Armco Welded Steel Pipe installed in pipe gallery of El Placer Water Purification Plant, Quito, Ecuador.

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ARMCO WELDED STEEL PIPE

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(Continued from page 38 P&R)

A Big Tea in Big D was the occasion at which these AWWA ladies were caught imbibing. The scene was the Terrace Room of the Baker Hotel on Apr. 21. Below, Mrs. Richard V. Ford, wife of the WSWMA president, pours while Mrs. Q. B. Graves, wife of the Southwest Section chairman, Mrs. W. J. Orchard, wife of AWWA's treasurer, Mrs. H. E. Jordan, wife of AWWA's secretary, and Mrs. W. F. Hoffman Jr., wife of WSWMA's Southwest Section chairman, smile as though it were water being poured. At left, Mrs. K. F. Hoefle (seated), chairman of the tea, visits with Mrs. Henry Graeser, ladies' general chairman, and Miss Helen Poe, travel lecturer and speaker at the tea.

(Continued on page 42 P&R)

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(*Continued from page 40 P&R*)

From portable to potable is the story of water supply in Asuncion, Paraguay, where a new public water system, including diversion works from a river, a filtration plant, and a distribution system to supply 250,000 people, is now being built with funds supplied by the US Export-Import Bank. As this potable water supply will not be available until sometime in 1959, the portable water supply—a cap, can, and cup system (see cut)—continues. The Asuncion system will be the largest—if not the shapeliest—ever built as a complete unit.

Water on top, rather than tap, now serves Asuncion, Paraguay, but the Ford Meter Box almost under the feet of the distribution sister bears promise of an early change from walking to running water.

Superior Service Awards have been granted by the US Dept. of Health, Education & Welfare to Franz J. Maier, sanitary engineer director, and Ervin Bellack, chemist, Div. of Dental Public Health, USPHS, for their invention of a fluorspar dissolver. This device, described by Maier and Bellack in their January 1957 JOURNAL article (pp. 34–40), can cut fluoridation costs two-thirds by making it possible to use fluorspar, the cheapest of all commercial fluoride-containing minerals, in conjunction with alum.

Also honored were William Marcus Ingram, biologist, and Abraham S. Goldin, chemist, both with the Robert A. Taft Sanitary Engineering Center and both familiar to JOURNAL readers. Dr. Ingram was cited for ability and effectiveness in water supply and pollution control and Dr. Goldin for his work as principal investigator in the development of techniques for analyzing radioactive contaminants.

Robert G. Burnside has been appointed sales manager by Ludlow Valve Mfg. Co., Troy, N.Y., to succeed the retiring Eric A. Rutledge.

Protection against lime scale, corrosion, and red water in small industrial and other water systems is said to be provided at low cost by the use of "Instantreat," a rapidly soluble complex phosphate, in conjunction with the Calgon Chemical Feed Pump. It is claimed that the water-operated pump, weighing 4½ lb, will provide continuous automatic treatment up to 10,000 gph when used with Instantreat. Both pump and phosphate are products of Calgon Co., Div. of Hagan Chemicals & Controls, Hagan Bldg., Pittsburgh 30, Pa.

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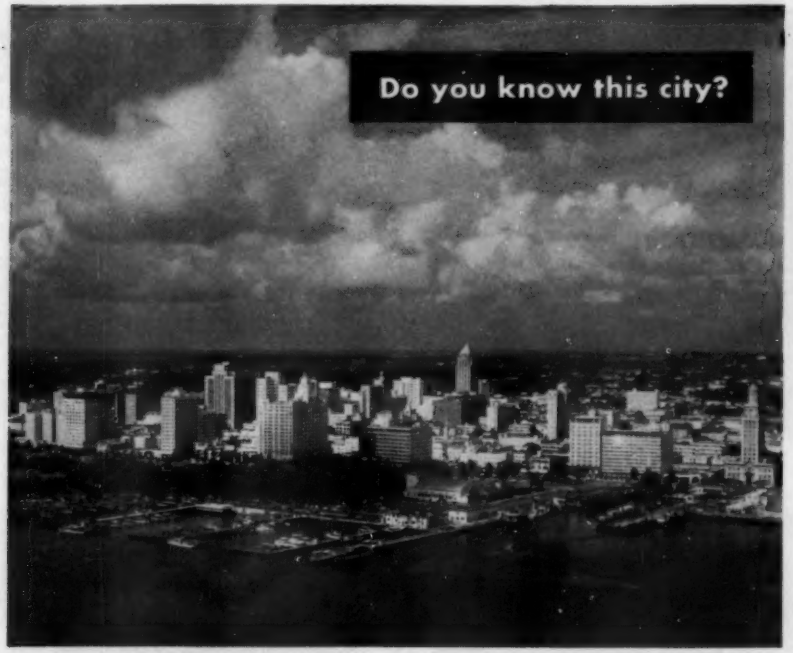

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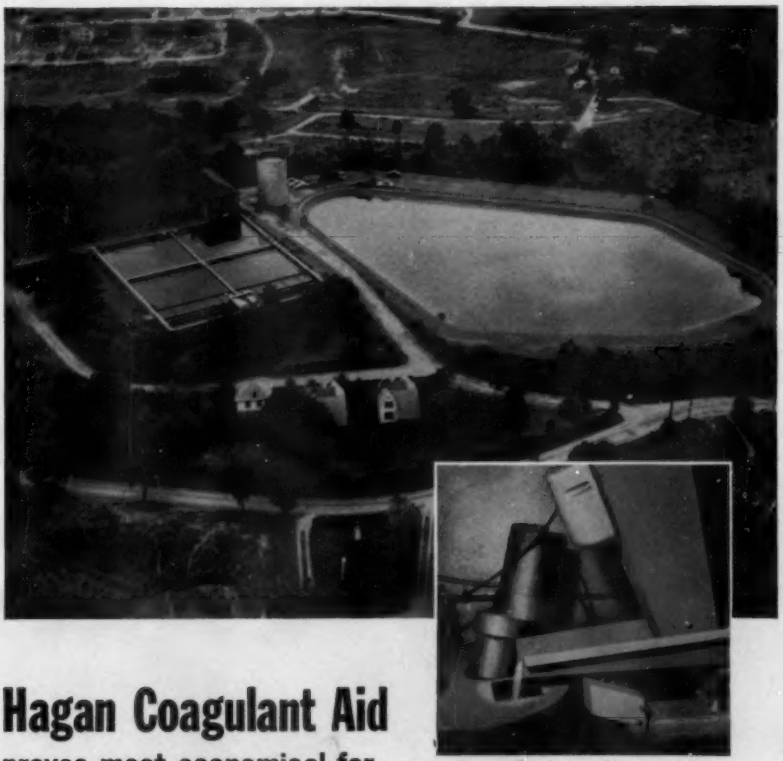
(*Continued from page 42 P&R*)

A comprehensive pollution abatement plan has been approved by the New York State Water Pollution Control Board for the Susquehanna River Drainage Basin, excluding the main stream of the river. (A plan for the main river was previously developed and approved.) The plan recommends specific steps by 41 industries, 19 municipalities, and 2 counties to bring the waters of the basin up to established standards. Following final adoption of the plan, meetings between board representatives and officials of the various municipalities and industries will be held to discuss means of correcting adverse conditions.

The cold war turned to ice last February with the reporting, by US Army scientists, of studies which revealed that "sea ice, such as that in the Arctic, can have twice the strength of fresh-water ice." This discovery, it appears, just goes to show that you can't trust a Russian, for it was Soviet scientist K. S. Moskatov who was credited with and now is to be blamed for establishing "the commonly accepted scientific rule of thumb that sea ice is three times weaker than [not, note, a third as strong as] fresh-water ice." The cold fact that Western scientists were willing 20 years ago to accept the "weak sea" rule on the basis of no more than "a vague statement . . . without experimental evidence" would seem to indicate that K. S. was considered as hot stuff then as Russian Sputnicians are now.

Now, if this seems to have little or nothing to do with our kind of water, consider the fact that high on the list of Army research needs is the "development of appropriate means of keeping the soldier's drinking water from freezing under Arctic conditions."

(*Continued on page 46 P&R*)



Hagan Coagulant Aid

proves most economical for Wilkinsburg, Pa., plant

Hagan Coagulant Aids are easy to feed. They can be dry-fed or fed as a solution. The Wilkinsburg plant uses this dry feeder to put Coagulant Aid No. 18 into solution.

The Wilkinsburg-Penn Joint Water Authority plant uses Allegheny river water that is high in manganese. Careful tests established lime, potassium permanganate and alum treatment to be the most effective method for manganese removal. However, the precipitate was finely divided, slow to settle, and carry-over of floc clogged filter beds.

To speed floc settling, the chief chemist tried both activated silica, and, with State Health Department approval, Hagan Coagulant Aid No. 18. Both were given laboratory tests and plant tests of several weeks' duration. At the end of the testing period, it was found that both gave equally good results at comparable chemical costs. However, the fact that Hagan Coagulant Aid could be dry-fed, while the preparation of the activated silica sol was a time-consuming task, made Hagan the obvious choice.

Nearly two years of usage has proved that Hagan Coagulant Aid works well with the other treatment chemicals over the full range of fluctuation in raw water characteristics. These Aids are non-toxic, easy to handle and feed, and produce a large tough floc that speeds settling time and reduces carry-over.

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(*Continued from page 44 P&R*)

Willing as we may be to apply the commonly accepted rule of thumb, credited to our own A. B. (Happy) Chandler, that vodka is three times weaker than bourbon, we are brought up short by the Army's specification "without the use of alcohol." It would have been a cold war, indeed, if salt had been the answer.

Unwilling Walter could have been the name of the live burro that Johns-Manville put in front of the 30-ft replica of a typical Texas town of 1858 at its AWWA exhibit in Dallas last April, but it was Walter's job to urge people not to be stubborn about backing AWWA's "Do It Now!" program of water works construction (see cut). The "Ring-Tite" label which Walter bears, J-M tells us, is the name of the joint in front of which Walter is parked—a joint in which tightness is said to be guaranteed. But Walter apparently took his job seriously and stayed outside, bright-eyed and tight-tied. *Do It Now!*

Parsons, Brinckerhoff, Hall & Macdonald, consulting engineers, has moved its New York City offices to 165 Broadway.

Richard L. Engel is the new manager of Allis-Chalmers' Industries Group—Pacific Region. Succeeding him as manager of the group's Los Angeles district is Donald E. Steele.

(*Continued on page 48 P&R*)

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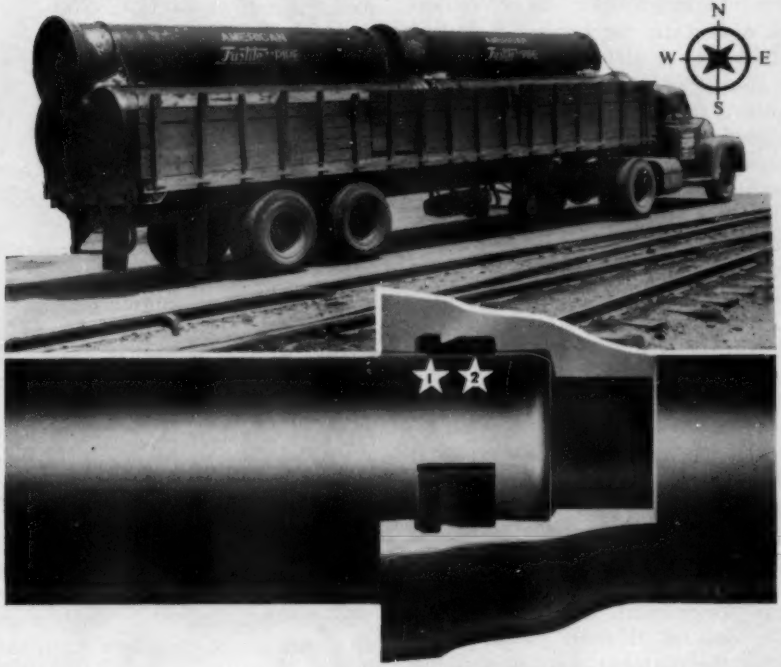

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(Continued from page 46 P&R)

Legal notes: *Service obligation.* The Wisconsin Public Service Commission has ruled that Milwaukee must furnish the neighboring city of Wauwatosa with water for resale. Rejecting Milwaukee's contention that one utility could not be required to supply another, the commission stated that Milwaukee, by providing water to a number of other municipalities, had "assumed an obligation as water public utility to provide such service to any municipal water utility" in Milwaukee County contiguous to the city. Not only must Milwaukee furnish 2 mgd to Wauwatosa as a temporary emergency measure, but it must "proceed with due diligence to provide such additional plant and facilities as are necessary to furnish Lake Michigan water for resale to the city of Wauwatosa on a permanent basis."

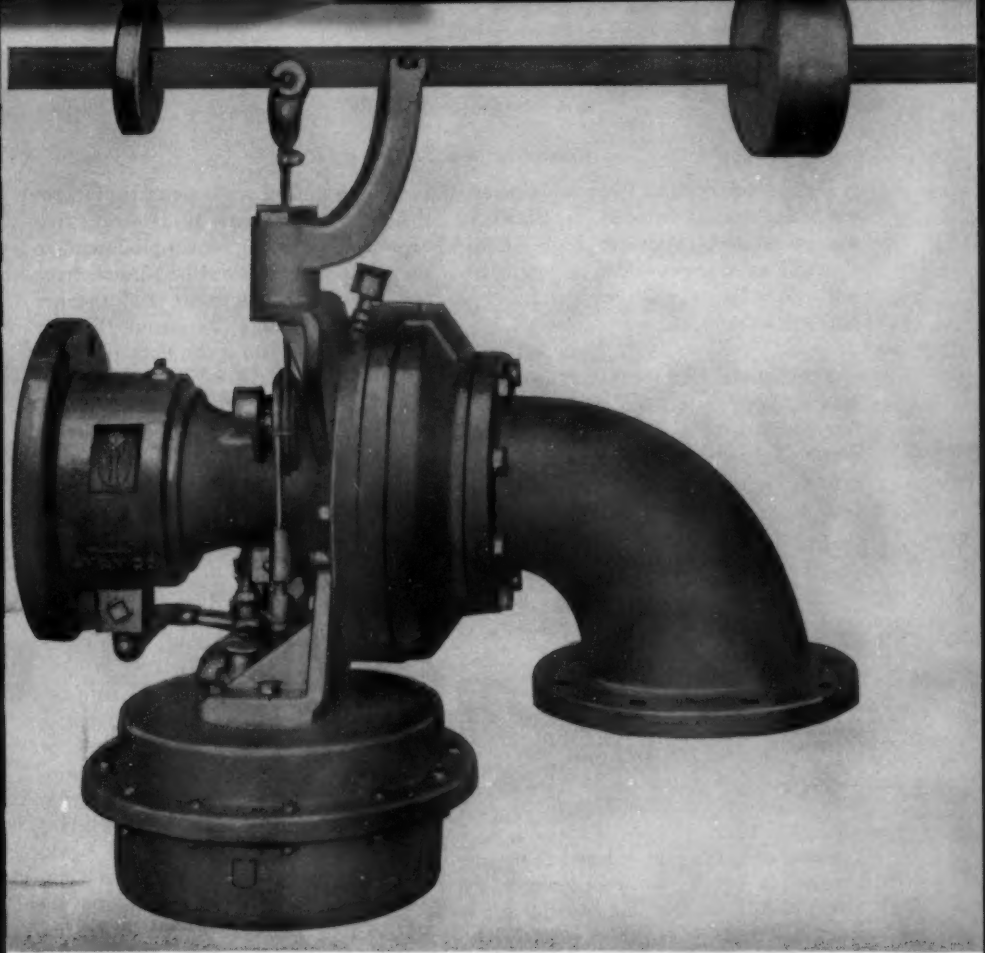
Fluoridation. The Supreme Court of Canada, by a vote of 5 to 2, has rejected the appeal of the Municipality of Metropolitan Toronto from an adverse lower-court decision. Flower Hill, one of thirteen municipalities within the Toronto metropolitan district, had brought suit to prevent the district from fluoridating the water supply. An original court ruling in favor of the district was overturned by the Ontario supreme court, and the district then appealed to the Supreme Court of Canada. The latter held that the Toronto Metropolitan Council, though authorized by statute to provide the inhabitants of the metropolitan area with "a continued and abundant supply of pure and wholesome water," did not have the right to fluoridate it, because such treatment was not required to make the water "pure and wholesome."

Speaking of fluoridation, the US Public Health Service reports that, as of May 1, a total of 1,644 communities in the United States were receiving fluoridated water. The population served amounted to 33,418,700.

Ladies first is what water has become—ladies' first choice, that is, for intensive study during the next 2 years, together with foreign policy. Such was the decision of the League of Women Voters at its recent 23rd national convention in Atlantic City, N.J., after 3 days of debate concerning primary goals. That water resources should have been continued as a first objective for study is particularly fortunate for the public water supply field, which was relatively neglected during the last period of study. Now AWWA is calling on all its members to come to the ladies' aid in supplying information and ideas to local units of the League of Women Voters to make certain that the ladies realize that their home water tap is their closest link with the water resources problem. Your troubles are their troubles and, as usual, it's in their power to solve them.

A real water pitcher is Harris Seidel, it appears—although strictly an underhanded one. Harris, who is water superintendent at Ames, Iowa, does his pitching for the local Moose softball team—and well, too, if his recent four-hitter against Ogden is any indication. What we liked though was the subtle publicity for the water department in the sports page headline: "Moose Rally Dips Ogden." We look forward now to "Moose Soaks Sac City," "Moose Drowns Davenport," "Moose Inundates Indianola," and, finally, to "Moose Flushed With Victory." After all, Harris is also superintendent of sewage treatment.

(Continued on page 50 P&R)



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(Continued from page 48 P&R)

De Laval Steam Turbine Co. announces the election of H. G. Bauer as executive vice-president and Harry Engvall as vice-president of engineering. Mr. Bauer will continue as general sales manager.

The mustached truck pictured here was snapped by one of P&R's Editors Anonymous on a street in Willamina, Ore. Actually the adornment is not hirsute, but tree root, pulled out of a 6-in. wood-stave water line serving the

community. Having entered the main through a crack, the root completely stopped flow in the line, setting off a hunt for a bad leak. A bad leech, rather!

A Winter mural weighing 420 lb now tells the story of how water is supplied to Cleveland, Ohio, through the new Clague Road Filtration Plant that will soon furnish 50 mgd to the west side of the city. The Winter involved is named Ed, and far from being a cold one, he deals in temperatures between 1,440° and 1,500°F in producing the enameled steel murals which he has pioneered. The one just installed on the walls of the Clague Road plant is 24 ft long and 5 ft high, and tells the story of water supply from the Lake Erie intake right through to the home faucet. The mural was produced in 42 different 10-lb panels that required ten firings each, following a design that was derived as much from the architects' blueprints and the engineers' drawings as from Wintry imagination. And more than just decorative, the mural is expected to be useful, too, in giving an introduction to plant tours, just as a similar, smaller one at Cleveland's Nottingham plant has already proved to be. And the full-page color feature story that the Cleveland *Plain Dealer* gave the mural in its Sunday supplement will not be the least of its benefits. Winter or summer, spring or fall, the story of water supply bears telling.

The TV world must, we suppose, be unreal to be entertaining, but it hardly seems necessary that they go quite as far overboard as was indicated by the synopsis of an episode of *The Californians* last Apr. 22. Having crashed through with a water works story during Water Works Week, the producers did well in not calling the fact to the attention of AWWA, then meeting at Dallas, for the story, called "Pipeline," went like this:

> A doctor complains about the unsanitary conditions of the local water supply. The man who controls the water retaliates by kidnaping the doctor's daughter. Marshal Matt Wayne is called in to locate the girl.

Of course, if the story made it clear that the kidnaping was merely a means of forcing the doctor to support a water rate that would enable the utility to provide the kind of water supply the doctor wanted, that would at least make the act understandable, for it is obviously dollars, not dolls, that water works men most need.

(Continued on page 86 P&R)

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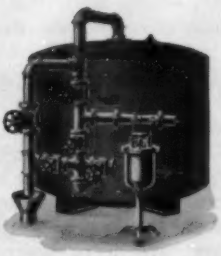

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Correspondence

Cooler Quirk Query

To the Editor:

The Brantford water utility has been faced with an unusual problem and we wonder whether any of your readers can suggest a solution.

We received a complaint that water coming from electric coolers and coffee and Coca-Cola coming from automatic dispensers were unpalatable. The customer charged that we had a dead-end condition that required flushing. It is true that this customer is on a main 6 miles from our plant terminating at his property, but the main is new and is of asbestos-cement.

We were able to show that the water coming from faucets on the premises was as good as the water direct from our plant. This amazed the complainants, who had not attempted drinking from faucets but had drunk only from the electric coolers. The cooler water and dispenser liquids, however, were indeed undrinkable, having a bitter, metallic, astringent taste.

We have written to several leading manufacturers of electric coolers and to the Coca-Cola people to ascertain the nature of these machines. We have learned that the electric water coolers generally contain a red-brass tank, hot tin dipped, with copper piping, cold tin dipped. Naturally such a setup may be connected to brass or galvanized-iron couplings at the direction of a local plumber, so it is obvious that more than one metal may be in contact with a small volume of water over a considerable period. The capacity of the coolers is said to be about 5 qt. The problem is not confined to one brand of cooler or to one location in town, and the only difference that we have noticed is that the taste varies in degree.

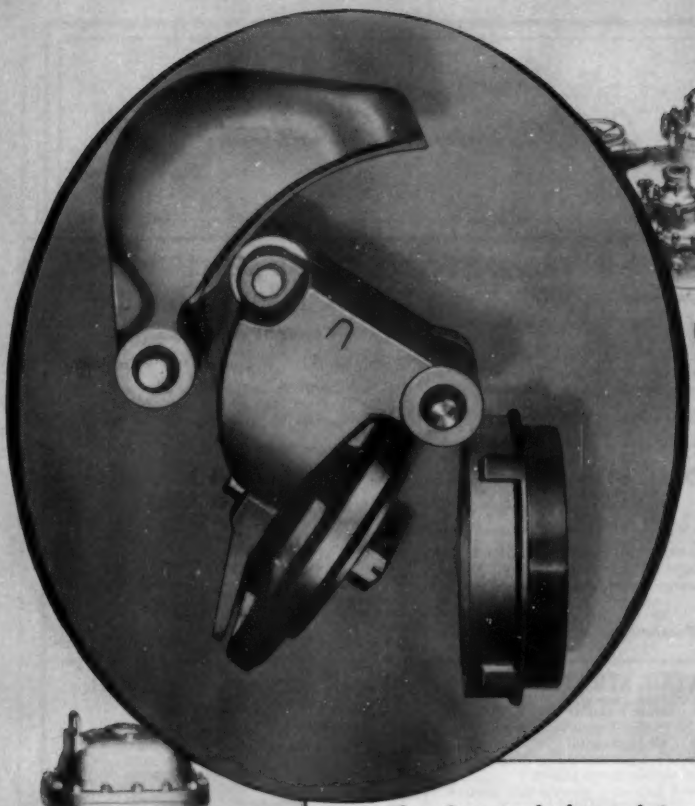
At the moment we feel that some metal or metals may be going into solution due to chemical corrosion, stray-current electrolysis, or electrolysis brought about by dissimilar metals being in contact with the water. While we intend to do some work in this regard we would like to have the benefit of others' experience with these coolers and similar equipment.

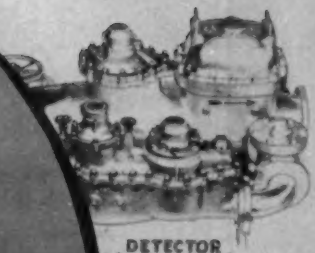
Treatment at Brantford includes alum, free residual chlorination, filtration, sodium silicofluoride, sulfur dioxide, and ammonia. The final water has a 0.3–0.6-ppm combined chlorine residual at the plant, pH 7.2–7.4, methyl orange alkalinity 175 ppm, total hardness 250–350 ppm (roughly half bicarbonate and half sulfate; calcium and magnesium both present; slightly aggressive to calcium carbonate), dissolved solids 300–400 ppm, dissolved oxygen zero to saturation depending on the condition of the river.

D. B. WILLIAMS

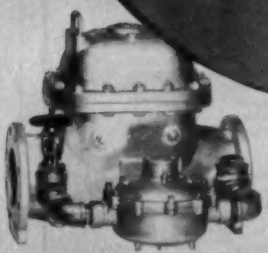
Water Works Chemist
Brantford, Ont., Apr. 24, 1958

Just before we went to press, Mr. Williams wrote again, saying that copper had been found in the water from the coolers (which have copper pipe connections) but not in ordinary tap water. "We have fairly well assured ourselves that copper is the problem. We have made taste tests on solutions of various metal salts, and the copper salt solution is the only one that matches the cooler water taste."—ED.

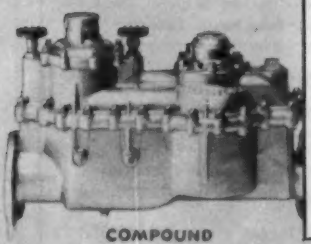




DETECTOR
(FIRE LINE)



DETECTOR CHECK



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Key: In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

CHEMICAL FEEDING, CONDITIONING AND SEDIMENTATION

Coagulant From the Ash of a Yugoslavian Coal. S. D. JANKOVIC & M. B. MILOJEVIC. Bul. Soc. Chim. Belgrade (Yugo.), 21:55 ('56). Ash of Jugoslavian coal had high content of aluminium and iron oxides. It was possible, by leaching with concd. sulfuric acid, to obtain useful coagulant from this for use in clarification of water. Product obtained was compared with alum.—*WPA*

Upflow Coagulation for Process Waters in the Pulp and Paper Industry. J. S. KNEALE. Tappi, 39:11:28A ('56). Illustrated description is given of design of some upward-flow coagulation and sedimentation tanks, and some results of operation are shown in tables.—*WPA*

A New Flocculating Agent. ANON. Water and Sanit. Eng. (London), 6:161 ('56). Mfrs. description and claims in respect of consumption, performance, and ease of handling for new coagulant, Separan 2610, are given. Material, synthetic org. water-sol. high mol. wt. polymer, is supplied as white amorphous solid, which is applied as dil. aq. soln.—*WPA*

Chlorinator Adjusts to Demand and Flow. ANON. Eng. News-Record, 159:3:69 ('57). Chlorinator that can maint. concn. of residual chlorine in accordance with chlorine demand and rate of flow of water is described. Chlorine residual required is controlled by operator. Main feature of new machine is electronic dosage controller. Diagram and description of method of operation of machine are given.—*WPA*

Stabilizing Water in a Suspended Aluminium Hydroxide-Chalk Bed. L. A. KUL'SKII, M. A. SHEVCHENKO, & V. P. CHUPOVA. J. Chim. Ukraine (U.S.S.R.), 22:542 ('56). Expt. was made in which river water was passed upward through suspension of aluminium hydroxide and chalk. Stability of product was detd. from ratio of alky. before to that after shaking for 2 hr with calcium carbonate. If ratio is found to be 1, then water is stable; if less than 1, it attacks metals; if more than 1, it has tendency to deposit calcium carbonate. In particular expt. made, ratio was less than 1, but greater the amt. of chalk used and smaller the pieces, closer ratio was to 1 and longer period before suspension lost its activity.—*WPA*

Flocculation at Sedimentation. Part I. A Study of Two-Particle Interaction. O. ANDERSON. Svensk Papperstidn. (Stockholm), 59:540 ('56). Flocculation of suspended particles requires that there should be attractive forces acting between particles. Such attractive forces frequently exist, but they decrease quite rapidly with distance. Relative motion of particles is required to make distances small enough to allow attractive forces to act. Such relative displacements occur with particles settling at different veloc. There is hydrodynamic interaction between sedimenting particles which is mainly repulsive. Deviation from vertical path of sedimentation during interaction between 2 particles is derived from fundamental hydrodynamic eqs., and it appears that, disregarding other than hydrodynamic forces, spherical particles will never touch each other during sedimentation. Validity of eqs. was tested by recording motion of pairs of small glass balls settling in glycerol using specially-designed 2-dimensional travelling microscope.—*WPA*

Aids for Water Conditioning. A. E. GRIFFIN & R. J. BAKER. Munic. Utilities Mag. (Toronto), 95:7:54 ('57). Several new types of chems. have been introduced to aid

(*Continued on page 64 P&R*)

FIRST OF TWO ELEVATED WATER TANKS FOR JOLIET, ILL.

A 7.4 million dollar water modernization and enlargement program started in 1947 will soon be completed in Joliet, Ill. This is another step forward in the growth of this thriving Midwest industrial community, which won the coveted All-American City Award several years ago. Two elevated water tanks, including the 250,000 gallon tank below, were designed, fabricated and erected by Graver.

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(Continued from page 62 P&R)

coagulation during water treatment. Authors classify coagulant aids into 5 groups, of which 5th group is relatively new. It is group of electrolytes which, by their ability to provide charged ions, aid coagulation and flocculation. Inorg. electrolytes in group are bentonite clay and activated silica. Series of org. polymers which are sol. in water form org. electrolytes. Theoretical explanation of action of these chems. is that they carry strong negative charge which supplements charge carried by the colloid particles. Full theory is under investigation. Aids are applied as liquids at point where floc has just begun to form. Conditioning aids are useful where floc formation seems incomplete, where floc produced tends to float, or break up before filtration, where there is wide variation in temp., and where filter runs are short. Authors give several examples showing how use of coagulant aids has increased eff. of water purif. plants.—*WPA*

Problems of the Sedimentation of Water Destined for Public Consumption. JULITTE. L'Eau (Paris), 42:117 ('55). Problems encountered in process of sedimentation during treatment of water, are enumerated. Various stages of process and their mechanism; difficulties caused by colloidal tendency and elec. charge of particles; use of various coagulants, amts. in which they are added, and method of application; necessity for catalytic effect of preformed sediment for satisfactory sedimentation; application of Stokes' law; and phenomena of agglutination and coalescence are subjects which are discussed in detail. Details are given of use of vertical and horizontal sedimentation tanks, and advantages of each type of tank are described. Author recommends use of vertical sedimentation tanks for greater eff. and suggests that smaller, more compact app. would be just as effective, besides being more economical and practical. Improvements in constr. and use of sedimentation tanks including automatic removal of sludge, and in sedimentation process, are also recommended. In discussion following paper, author's preference for vertical sedimentation tanks is questioned by LEVIEL; usefulness of smaller, compact units is criticized by GUILLERD; and BOUCHARD criticizes sole application of Stokes' law to process, stating that satisfactory sedimentation depends on other important factors, including application of Freundlich's law.—*WPA*

DISINFECTION

The Effect of Bactericides On the Microorganisms in Oil Flooding Waters. K. E. ANDERSON & F. YACKOVICH. Sci. Studies, St. Bonaventure Univ., 17:33 ('55). Bactericidal eff. of various compds. for disinfection of water for flooding oil fields was investigated. Bact. flora of water and ability of organisms to develop resistance to bactericide, are important in selecting disinfecting agent. It was found that, in water treated with quaternary ammonium compds., *Pseudomonas* predominated. Organisms which developed resistance to 1 quaternary ammonium compd. did not develop resistance to another, and this suggests that 2 such closely related compds. could be used for intermittent treatment of flooding water. Quaternary ammonium compds. tested were more bactericidal and less bacteriostatic than was org. mercurial compd. Mercury compd. was not effective for disinfection of brine. —*WPA*

Practical Experiences with Ozone Plants in Town Water Works. G. E. KURZMANN. Kommunalwirtschaft, p. 371 ('56). Ozone treatment ensures odorless and tasteless water but costs of operation of plant are higher than with chlorination. Construction of ozone treatment plants and experiences with some German plants are described. In Rottenburg, addn. of 0.3 g ozone/cu m was insufficient at times of high rainfall and had to be supplemented by chlorination; it is planned to increase ozone dosage to about 3 times present amt. and omit chlorination. in Neustadt, river water with bact. numbers up to 47,000/cc is successfully treated by ozone. Costs are discussed.—*WPA*

Comparative Studies on Physical and Chemical Methods of Water Sterilization for Use in the Brewing Industry. J. ZYWIEL & O. SKIBA. Prace Inst. i Lab. Badawczych Przemyslu Rolnego i Spozywczego (Warsaw), 6:3-4:79 ('56). Technical and economic aspects of disinfection of water for breweries by chlorination, ultraviolet radiation, and treatment with silver were compared. All 3 methods were equally effective,

(Continued on page 66 P&R)

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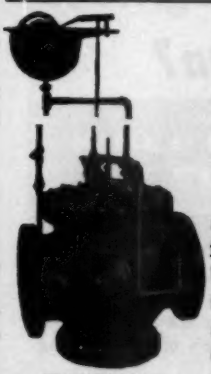

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(*Continued from page 64 P&R*)

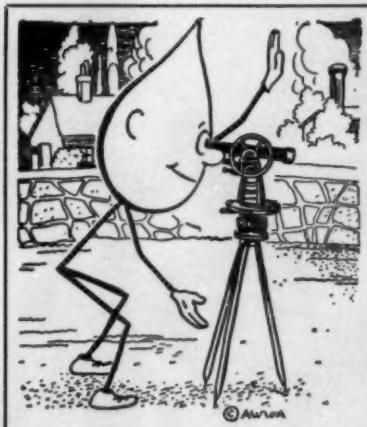
and chlorination is cheapest. Disinfection by oligodynamic action of silver, though expensive, is simple and easy and can be used for disinfecting equip.—*WPA*

Contribution to the Problem of Ultraviolet Disinfection of Water. W. ZIMMERMANN. Z. Hyg. Infektionskrankh. (Berlin), **143**:91 ('56). Results are given showing effect of treatment of small water supply with ultraviolet rays over 1 yr. Untreated water had very high bact. count and *coli* titre of 1 cc. Water was very hard and neutral in reaction, and contained normal amts. of org. matter and salts and 0.3 mg of iron/l. 2 ultraviolet mercury low-pressure lamps irradiated channel in which water flowed in layer 3–4 cm deep at rate of 18 cu m/hr. After irradiation, water was bacteriologically satisfactory throughout distr. system.—*PHEA*

Disinfection of Water by Ultrasonic Waves. L. N. FALKOVSKAIA. Gigiena i Sanit. (Moscow), **21**:1:11 ('56). Author describes investigations on bactericidal action of ultrasonic waves on *Bact. coli, Bact. aerogenes,* and *B. subtilis.* Bactericidal action was not affected by thickness of water layer up to 10 cm. Main mass of bacteria was killed by exposure for 2–5 sec. Action was independent of turbidity, was equally great on vegetative and spore-forming organisms, and depended mainly on intensity. At 1.8 w/sq cm, 99–99.8% of bacteria were destroyed.—*WPA*

Further Quantitative Studies on the Reaction of Chlorine With Bacteria in Water Disinfection. 2. Experimental Investigations With Cl^{36} and P^{32}. L. FRIBERG. Acta Pathol. Microbiol. Scand., **40**/1:67 ('57). Reaction of chlorine with bacteria (*Esch. coli*) in water disinfection was studied under different conditions. Investigations are continuation of study previously recorded (Friberg, '56). Reaction with bacteria was investigated partly with aid of radiochlorine (Cl^{36}) and amperometric titration of free and combined available chlorine and partly

(*Continued on page 68 P&R*)



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(*Continued from page 66 P&R*)

by studying bacteria labeled with radiophosphorus (P^{32}). In latter expts. it was especially investigated how much of bact. phosphorus after chlorination could be released from bacteria. These investigations were carried out to form impression on extent of destruction or permeability change of bacteria which occurs on chlorination. In certain instances, comparisons were made with bacteria killed by heating or with benzalkonium chloride or phenol. *Esch. coli* was used in concn., on average, of about $50:10^6$ bacteria/ml water. With certain exceptions, period of exposure of bacteria to chlorine was 5 min and amt. of chlorine added was about 0.5 ppm free available—in certain expts., combined available—chlorine. Expts. were carried out at water temp. of about 20°C. and pH values of about 6.5 and 8.2. 5 graphs and 11 tables given.—*PHEA*

Biological Disinfection in Surface Waters. R. Wohlrab & Emeis. Zentr. Bakteriol., Parasitenk, Abt. I Ref. (Ger.), **163**:311 ('57). Report of paper presented at meeting of Osterreichische Gesellschaft fur Mikrobiologie und Hygiene in Sep. '56. Comparison of hygienic and chem. values for surface waters with biol. results over yr shows close relation between variations in these values and presence and activity of algae. Lab. expts. showed presence of active principle in green and blue algae and diatoms which, depending on light and thus on activity of assimilation, increases content of oxygen in water, increases decomposition of nitrate, and reduces bact. numbers and numbers of *Bact. coli*. This action, being dependent on light, does not affect bacteria below depths of 1 m, in turbid water, or at night. Certain algae have, however, antibact. action which is independent of light and may at times be very strong. Dependence of effect on emission of oxygen by algal cell and possibility of emission of atomic oxygen are discussed, and types of bacteria affected are given. Importance of this biol. disinfection and methods of ensuring its full utilization are considered. —*WPA*

Experimental Determination of the Conditions Necessary for the Purification of Drinking Water by Means of Silver Preparations. W. Oberzill. Arch. Hyg. (Ger.), **141**:217 ('57). There have, at times, been adverse accts. of eff. of silver for disinfection of water, and series of expts. were carried out on disinfection of artificially contamd. water, to det. effects of initial numbers of polg. organisms, variations in dose of silver, differences in phys. and chem. compn. of water, effects of temp. on rate of disinfection, and sensitivity of different polg. organisms to silver. Results of expts. are given and discussed. It is concluded that unsatisfactory results of disinfection by silver are attributable to use of method under unsuitable conditions.—*WPA*

FLUORIDATION

Fluorine in Teeth of Israeli Children, in Relation to Fluorine In Domestic Waters and to Dental Caries Prevalence. J. Gdalia & J. Yardeni. J. Dental Research, **36**:203 ('57). Detn. of concn. of fluoride in 127 intact shed primary teeth from 114 children in Israel living in places with different drinking water supplies showed that there was distinct relation between low fluoride concn. in water and teeth with high dental caries index, and that opposite was also true. Further investigations are necessary to det. causes of individual differences in concn. of fluoride in teeth of children from same region and in different teeth of same individual.—*WPA*

Grand Rapids Fluoridation Study—Results Pertaining to the Eleventh Year of Fluoridation. F. A. Arnold Jr. Am. J. Pub. Health, **47**:539 ('57). Effect of fluoridation of water supplies of Grand Rapids and Muskegon, Mich., during last 11 yrs, on occurrence of dental caries, fluorosis, and general health are summarized in tables and graphs. Tables showing comparison between results for Grand Rapids and those for Brantford, Ont. and Newburgh, N.Y. are included. Study of teeth of children between ages of 4 and 16 indicated that fluoridation reduced occurrence of dental caries and did not increase degree of fluorosis; nor was fluoridation considered detrimental to general health. —*WPA*

Fluoridation Is Major Accomplishment of Greater Winnipeg Water District. Munic. Utilities, **95**:5:27 ('57). Difficulties encountered prior to fluoridation of water supplies

(*Continued on page 70 P&R*)

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(*Continued from page 68 P&R*)

of Greater Winnipeg Dist. are described. These mostly involved legislation, as water supplies of surrounding towns are obtained from Winnipeg and consent of various towns had to be obtained before fluoridation could be employed. Fluoridation of water supplies of whole dist. is now carried out using sodium silicofluoride. Data relating to pop. served, water consumption, and costs of all projects and repairs carried out up to '56 are given. Details of recent repairs to distr. system are included and possibility of construction of new aqueduct is discussed.—*WPA*

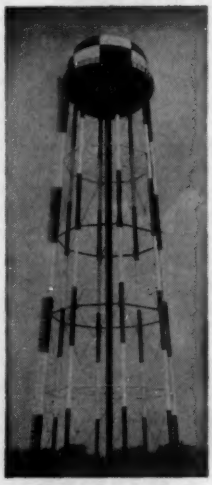
Installing Fluoridation Equipment in a Small Water Plant. A. P. KENNEDY. Munic. Utilities, **95**:3:21 ('57). Fluoridation of water supplies at small water works, generally, and at water treatment plant of Toronto Township, Ont., in particular, is considered. Author discusses merits of sodium fluorides and sodium silicofluoride, and methods and points of application of chem. At Toronto Township, sodium silocofluoride, in form of soln., is applied after filtration at taste control chamber by manually controlled machine.—*WPA*

The Effect of Fluoride on Dental Conditions. J. FORREST. Chem. & Ind., p. 64 ('57). Author reviews results of studies conducted in US, Can., and U.K., on effect of fluorine in drinking water on dental caries in children. In all cases it has been shown that concn. of 1 ppm fluorine in drinking water will reduce incidence of dental caries; if consumed from birth, this reduction is about 60%. Higher fluorine concns. will produce undesirable white and brown mottling and pitting of teeth.—*WPA*

Continuous Recording of Fluoride in Water. F. J. MAIER & E. BELLACK. Am. J. Pub. Health, **47**:1296 ('57). Techniques of 2 methods of obtaining continuous record of fluoride concn. are outlined. Device using cond. measurement as its method is described

(*Continued on page 72 P&R*)

WATER STORAGE TANKS



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(*Continued from page 70 P&R*)

in detail. Device used double distn. with 2nd distn. taking place in specially designed flask. 2nd device measures absorbency using ECR fluoride colorimetric test. Reagents and sample are fed by automatic pipets and soln. is mixed and then allowed to flow through colorimetric device.—*PHEA*

What Do We Expect From Fluorine Treatment of Water Supplies? A. Rost. Zabnarztl. Rundschau (Ger.), **64**:83 ('55). Investigations in 27 places around Jena, where avg. concn. of fluoride in water supplies is 0.8 mg/l, showed no relation between fluorine content and occurrence of caries in milk teeth and permanent teeth. Incidence of caries was not less than in places with fluorine contents of 0.11–0.21 mg/l. Author concludes that artificial addn. of fluorine to water supplies will not reduce caries.—*WPA*

Is There a General Agreement on the Advantage of Fluoridation of Drinking Water for Caries Prophylaxis? S. Palazzi. Athena (Rome), **22**:222 ('56). Recent studies denying favorable effect of fluoridation on dental caries are reviewed. 20 references.—*CA*

LABORATORY METHODS

Continuous Measurement of Turbidity in Water Technology. B. Weiss. Monatsbul. Schweiz. Ver. Gas- u. Wasserfach., **37**:185 ('57). Illustrated description is given of Sigrist photometer by which penetration of light through water and scattering of light by turbidity can be continuously recorded. App. can be used in water plants before filters to show changes in condition of raw water and after filtration to show any variations in clarity of treated water.—*WPA*

New Water-Sampling Apparatus. R. H. Laun. Gesundh. Ing. (Ger.), **77**:150 ('56). 2 forms of water sampler, suitable for bact. work and developed by National Bact. Research Station at Würzburg are described. First operates pneumatically, is suitable for depths of less than 10 m, and can be used in well shafts and bores. Second is electromagnetic app. for use at greater depths (up to more than 100 m), suitable for rivers, lakes, and res. Diagrams are given and methods of use are described.—*WPA*

Principles and Problems in Development of a Dissolved-Oxygen Analyzer. H. S. Levine & R. S. Kleinschmidt. Sew. & Ind. Wastes, **29**:856 ('57). Authors describe development of design of app. suitable for continuous detn. of oxygen in water over range of 0 to 150% of saturation at 0°–35°C, with accuracy of ±5%.—*WPA*

A Portable Temperature-Chlorinity Bridge for Estuarine Investigations and Sea Water Analysis. B. V. Hamon. J. Sci. Instr., **33**:329 ('56). Illustrated description is given of portable direct-reading instrument for measurement *in situ* of temp. and chlorinity of sea water and estuaries; ranges are 0–30°C for temp. and 0–16/1,000 and 16–20/1,000 for chlorinity. Measuring head, containing thermistor for temp. measurement and conductivity cell for measurement of chlorinity, is lowered into water; it is connected by cable to shipbroad unit containing bridge circuits, oscillator, detector, and batteries. Operating experiences and degree of accuracy obtained are described.—*WPA*

Instrumentation Used in Water Analysis. R. D. Wood. Eng. Progr. Univ. Fla., **10**:5:29 Bul. Ser. No. 79 ('56). In paper presented at Seventh Annual Southeastern Symposium on Industrial Instrumentation, 1956, author points out importance of accurate and rapid sample anal. in maintenance of satisfactory conditions in steam-generating systems, and describes constr. and operating principles of electrophotometer, pH meter, and conductivity meters used to det. concn. of dissolved solids and relative acidity and alky. of water, steam, and condensate in such systems. Reference is also made to instruments used to control flow of chems. required for treatment of and addn. to boiler feed make-up water.—*WPA*

Calculation of Oxygen Percentage Saturation of Water. R. Burkard. Mitt. Lebensm. u. Hyg. (Bern), **47**:409 ('56). O_2 calculator consists of circular nomogram operating on sliderule principle, and provided with scales for ascertaining concn. of D.O. from anal. data, percentage saturation of O_2 from concn. of O_2, and altitude and temp. of source. Conversion of O_2 concn. to percentage saturation is based on data given by Truesdale et al. Calculator can be applied to data for sea water.—*PHEA*

(*Continued on page 74 P&R*)

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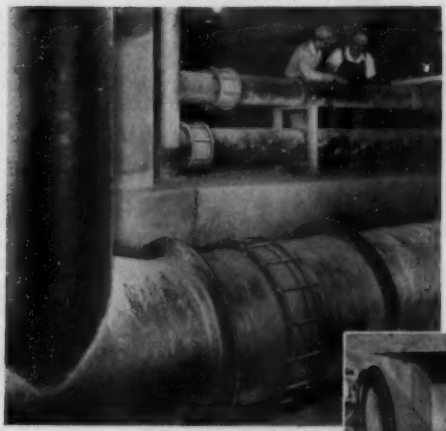

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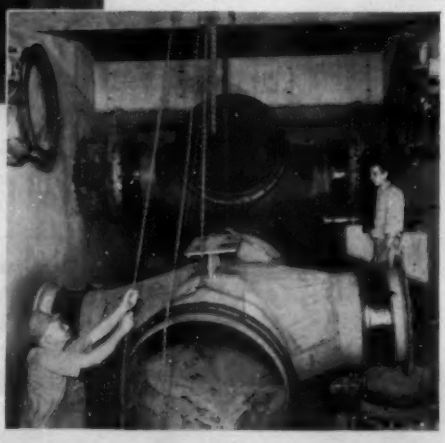

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(*Continued from page 72 P&R*)

Water Analysis. S. K. Love & L. L. Thatcher. Anal. Chem., **29**:722 ('57). Review of major work published in field of water anal. during years 1955 and 1956 is presented. Subjects covered include instrumentation, flame photometry, alk. earth metals, copper, zinc, iron, aluminium, trace elements, selenium, boron, chlorides, bromides, iodides, fluorides, sulfates, phosphates, silica, nitrogen compds., dissolved gases (including oxygen and chlorine), org. compds., synthetic detergents, B.O.D., and chem. oxygen demand, radioactivity, uranium, radium, thorium, isotopic anal., detn. of low concns. of acidity or alky., water-formed deposits, turbidity, and ion-exchange methods of anal. Bibliography of 302 references is given.—*WPA*

Emission Spectrum Analysis in Water Chemistry. W. Christ. Chem. Tech. (Berlin), **8**:280 ('56). Brief survey is given of development of spectrum anal., possibilities of method, and its use in water chemistry. Photometric detn. of calcium in sugar refinery waste waters contg. phosphate, and quant. spectrographic detn. of rare alkalis and alk. earths in river water, are described. In presence of phosphate, calcium may be detd. by difference method. Content of calcium oxide is detd. before and after addn. of known amt. of lime and percentage by which result for added lime is too low is used in calcg. true content of sample. In second method interfering phosphate is pptd. as ferric phosphate by addn. of solns. of urotropin and ferric chloride; ppt. is filtered off and filtrate examd. photometrically. With very pold. waters, difference method gives better results. Spectrographic detn. of rare alkalis and alk. earths using different types of Zeiss spectroscopes is described, and results of anal. of water from river Saale are given.—*WPA*

A Rapid Method for the Characterization of Enteric Pathogen Using Paper Discs. A. C. Sanders; J. E. Faber; & T. M. Cook. Appl. Microbiol., **5**:36 ('57). Method has been developed for characterization of patho-

(*Continued on page 76 P&R*)

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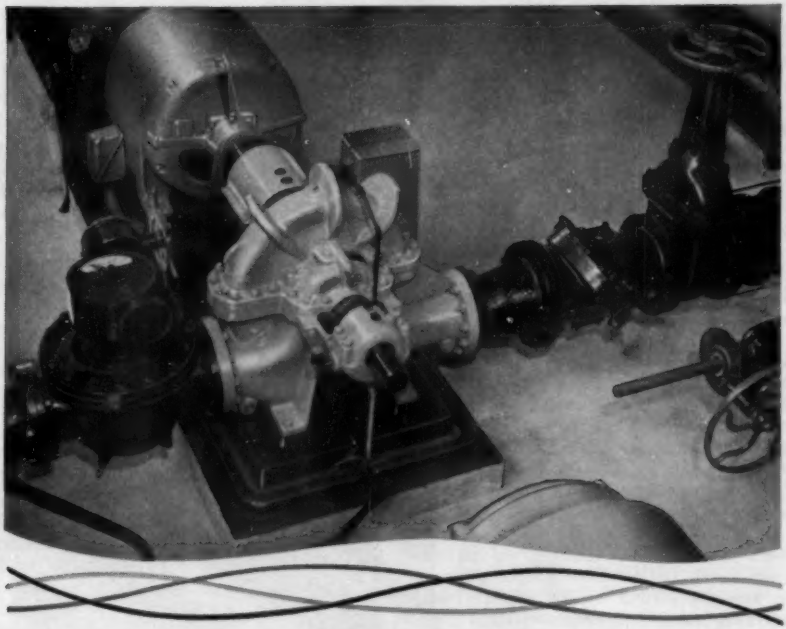

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(Continued from page 74 P&R)

genic enteric bacteria in less than 24 hr, using modified phenol red agar base medium. Nonlactose-fermenting colonies were selected from *Salmonella-Shigella* and MacConkey's agar plates after incubation for 15 hr, and were then incubated for 2 hr in lactose-sucrose booster broth, after which all tubes showing acid reaction were discarded. Petri dishes contg. modified phenol red agar base medium were inoculated with 0.15 ml from each of remaining tubes, and 4½-in. paper discs, impregnated separately with lactose, glucose, mannitol, and sucrose, were placed on surface. After incubation for 6 hr it was possible to detect acid formation by yellow zones around discs, and gas production was shown by splitting of medium within these zones. Hydrogen sulfide formation was also shown after 6 hr by black bands encircling acid zones. Kligler's iron agar medium was used in control tests and excellent correlation was obtained. Procedure is shown in form of diagram and results are given in table. Details are given of compns. of lactose-sucrose broth and modified phenol red agar base medium. Total of 206 cultures were used in testing this procedure.—*WPA*

New Apparatus. ANON. Bul. Centre Belge Etude et Document. Eaux (Liege), No. 62, p. 67 ('56). **I. Continuous Measurement of the Turbidity of Water.** Components of 4 new types of instrument, for continuous measurement of turbidity of water are given in table. 1 instrument, used to measure turbidity of Rhine at Wesel, is described. **II. Centrifuging and Vacuum Filtration.** Centrifuge and vacuum filter have been installed at labs. of Centre Belge d'Etude et de Documentation des Eaux, for use in studies on treatment of waste waters. Vacuum filter is described.—*WPA*

A Description of a New Zooplankton Counter. J. WARD. Quart. J. Micr. Sci., 96:371 ('55). Detailed description is given of constr. and use of new plankton-counting cell which consists of annular groove machined in circular plate of lucite so that width of bottom of groove corresponds with field of vision. Plate is rotated on turntable and driven at rate of about 1 revolution in 6 min. Advantages of rotating cell over conventional counting cells are discussed.—*WPA*

TREATMENT—GENERAL

Practical Experiences and Results of New Processes of Water Treatment—Mibis, Iso, Ozone. A. JUNG. Arch. Badewesens (Ger.), 9:98 ('56). After short survey of history of treatment of swimming-bath water, author describes Mibis process. In this process, pH of 9.5 must be maintd. in bath; at this value hypochlorous acid is dissociated and chlorine odor is largely absent. High pH value is obtained by circulation of water over alk. filter material. Chlorine content of 2 mg/l must be present at bath outlet. High chlorine content destroys org. matter and coagulants are unnecessary. Bactericidal effect is excellent. Author then discusses permissible loading of bath, using factor obtained by dividing daily number of users by number of cu m of water circulated in 24 hr. Factor 1 is permissible limit, 0.5 is desirable, and 0.3 meets highest requirements. With coagulation processes, amt. of water circulated in 12–14 hr is used and factor of 0.8 is adequate, 1.0 is limiting value, and 1.6 highest limit. At swimming bath at Bremen using Mibis process, chlorine odors occurred, as it was not possible to maintain required high pH value; this is ascribed to high carbonate hardness of water which was pptd. on filter material and prevented transfer of magnesium oxide to water. In Sweden, where Mibis process originated, waters used are generally soft and this trouble does not occur. Isochlorine gas process is briefly described but is considered too complicated for general use. Finally, author deals with ozone treatment which he hopes will in time replace chlorination. Difficulty is that it is not so far possible to store ozone in water.—*WPA*

Treatment of Water and Waste Water by the Accelator Process. W. WISFELD. Vom Wasser (Ger.), 23:148 ('56). Author gives description, with diagrams, of plant for Accelator process of treatment of water and discusses results and advantages of process. Results are given of treatment of pold. river water, showing high deg. of removal of color, 50% reduction in permanganate demand, removal of aggressive carbon dioxide, and reduction of iron from 0.8 to less than 0.03 mg/l. Use of process for treatment of waste waters from paper factories is then discussed and results are given of such treat-

(Continued on page 78 P&R)

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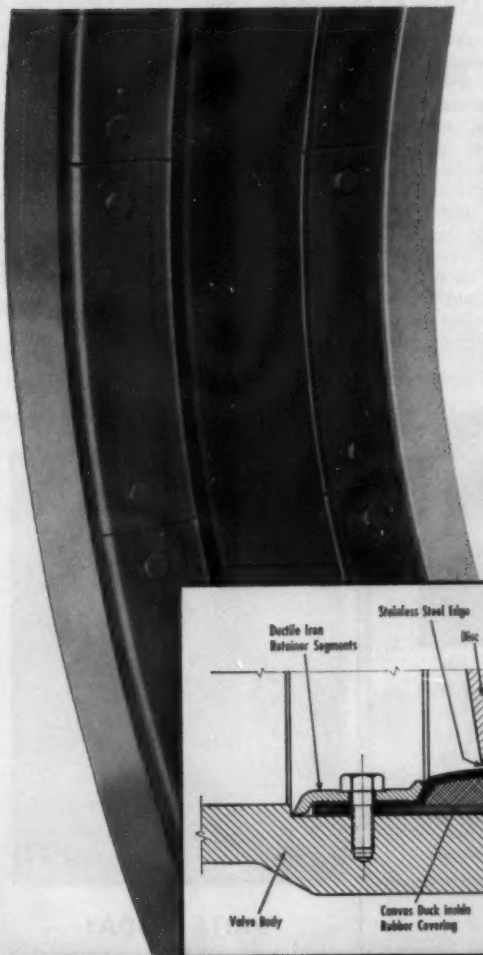

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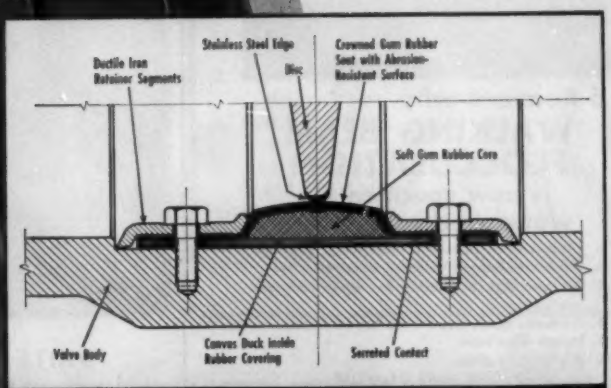

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(*Continued from page 76 P&R*)

ment. Adaptation of plant for biol. treatment of sewage is described, in which circulation is maintd. by blowing in finely divided air. Results of operation show 92% reduction in BOD and 95% reduction in solids. —*WPA*

Water Treatment for Recirculating Systems. C. W. DRANE. Chem. Ind., p. 1367 ('56). Author outlines problems encountered in cooling water systems and briefly describes treatment given to feed water of once-through and closed-circuit cooling systems. More detailed acct. is given of treatment methods used for prepn. of water for cooling-tower recirculating system, where evapn. and carryover in tower lead to concn. of dissolved solids in water, modification of concns. of dissolved gases, and of pH value when acidic gases from industrial atm. are taken into soln. Prevention of scale formation, of corrosion of metal parts in cooling system by control of pH value and addn. of inhibitors, control of org. slimes, algae, and macroorganisms by chlorination and use of other chems., treatments to remove suspended solids from feed water, and measures taken to control decay of timber and attack on concrete are discussed.—*WPA*

Design of Plants and Treatment Methods for Small Drinking Water Supplies Where Approved Public Supplies Are Not Available. E. L. E. ZAHM, ET AL. Am. Ry. Eng. Assoc., Bul., **58**:424 ('56). Sources of small drinking water supplies at isolated locations are described along with methods of obtaining desired characteristics by treatment methods, including filtration, aeration, chlorination, activated carbon, softening, and iron removal.—*PHEA*

Results of Observations From an Experimental Design Regarding the Treatment of Water By Means of a Spinning Flocculating Bed. S. MACKRLE, ET AL. Wasserwirtsch.-Wassertech. (Ger.), **7**:428 ('57). Equip. and its operation are described for

(*Continued on page 80 P&R*)

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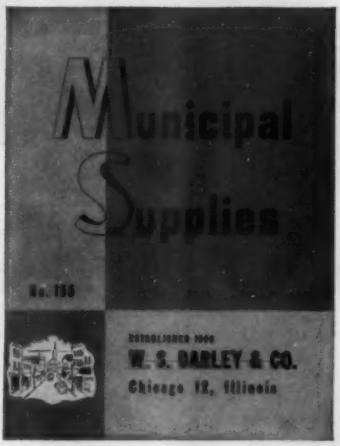

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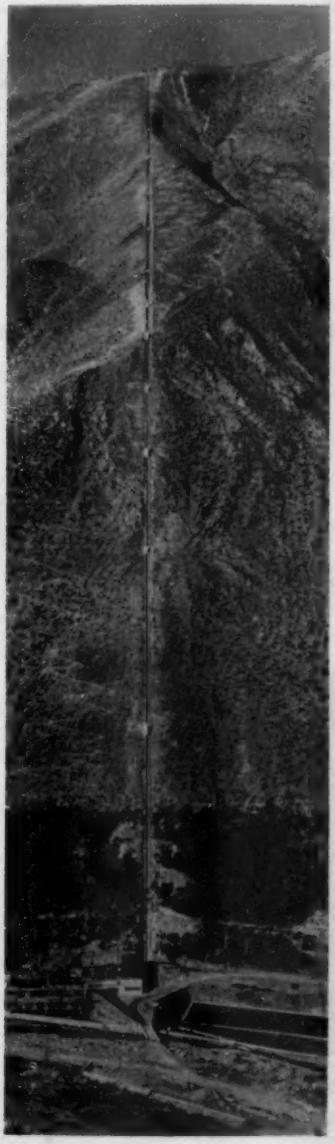

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(*Continued from page 78 P&R*)

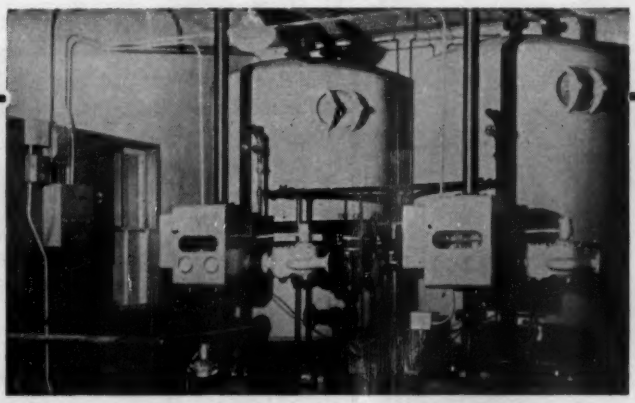
purif. of water by using spinning bed contg. flocculant. View of exptl. design, diagrammatic sketch of clarifier, and illustration of spinning bed, including pumping arrangement, are given. Principle of purif. of water by described equip. is discussed. Flocculating bed contains microflakes which are formed in perikinetic coagulation phase. All types of mechanical mixing devices can serve as paddle wheels in mixing chamber. These are considered from point of view of their applicability in process.—*CA*

Some Studies of Ozone for Use in Water Treatment. R. S. INGOLS & R. H. FETNER. Proc. Soc. Water Treatment and Examination, **6**:8 ('57). First part of paper reviews methods which have been recommended for detn. of ozone in water and describes some expts. of authors. At pH of 9.0 and at 1°C it is concluded that 1 molecule of ozone liberates 1 molecule of iodine. Other methods include oxidation of manganous ion to manganic and measurement with orrhotolidine, oxidation of bromide at pH 2.0, and oxidation of ferrous ion to ferric ion at pH 2.0. None of methods differentiates ozone from other oxidants such as chlorine. In tests of bactericidal effects of ozone soln. against *E. coli* suspensions at 1°C it was found to be lethal where detectable residual of ozone was present. In expts., 0.4–0.5 mg/l was concn. found effective. Discussion follows main paper.—*PHEA*

WELLS AND GROUND WATER

Chemical Configuration of Underground Water. A. HERMAN. Bul. Centre Belge Etude de Document. Eaux (Belg.), **27**:37 ('55). Method of classification of underground water is outlined and author then discusses amt. of ions present in underground water and action of this water on cryst. and sedimentary rocks. Explanation of total qual. of dissolved salts in underground water

(*Continued on page 82 P&R*)



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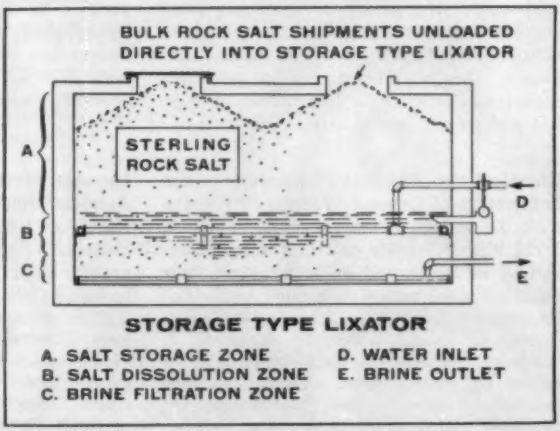

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(*Continued from page 80 P&R*)

as function of depth is given and detn. of quant. of dissolved salts by means of depth meter is described. Relation between quant. of dissolved salts in underground water and degree of ground heat is expressed, and pH value of underground water is discussed.—*WPA*

New Methods of Biological Investigation of Ground Water. C. MUEHLBERGER. Wasserwirtsch. Wassertech. (Ger.), **6**:45 ('56). Author discusses importance of biol. examn. of ground water and its practical application. Knowledge of types and communities living in different ground waters is valuable supplement to chem. and bact. examn. Author gives names of numerous organisms characteristic of different types of soil and ground waters.—*WPA*

Chemical and Physical Phenomena in the Infiltration of Ground Water. F. NORING. Pub. **37**, Assoc. Intern. Hydrologie (Fr.), **2**:113 ('56). Author describes, from observations in Switz. and on lower Main, how effect of river water on ground water can be detected, even where there is no withdrawal of ground water, by variations in hardness, and gives factors responsible for extent of mixing area. Chem. reactions causing increase of iron, manganese, and hardness during passage of water through ground are discussed. As example, case is described of water works of town of Hanau where increase in contents of iron and manganese following damming of Main made some wells unusable. Cooling processes when warm water is dischgd. to ground water are investigated and formula is given for calcg. temp. to be expected on withdrawal of water at given distances. Permeability of river banks, which is affected by content of suspended matter in surface water by ice and by flood water, can be detd. only by expt.—*WPA*

Detection and Collection of Ground Water. T. BRINKHAUS. Neue Deliwa Z. (Ger.), **2**:39 ('57). In Ger., 80% of water used for domestic supply is ground water. Methods for finding ground water vary with geology of district and depth of ground water. Methods of prelim. work carried out for Coblenz water works are described. Whole area was investigated by borings and natural flow of ground water was followed by gaging wells. Constr. of various types of wells is described.—*WPA*

Recharging Ground Water by Irrigation. W. A. HALL; R. M. HAGAN; & J. D. AXTELL. Agr. Eng., **38**:98 ('57). Method of recharging ground water by applying irrig. water to 3 yr-old crop of lucerne was studied. Water was applied for periods ranging from 1 wk. to continuous application for 7 wk. during which lucerne was dormant. There were no ill effects on growth of lucerne if tops of plants remained above water. Weed control was complete when water level was maintained for 2 wk. during dormant period, providing weeds were fully submerged.—*WPA*

Increase of Ground Water Resources by Artificial Recharge. S. BUCHAN. J. Sci. Food Agr. (London), **8**:616 ('57). Author discusses advantages of artificial recharge of ground water supplies, geological factors to be considered before recharge of aquifer, sources of recharge water, and prelim. treatment of water used for recharge. Methods of infiltration and of abstraction of artificial ground water are described. Use of the rivers Thames, Trent, and Severn as sources of water for recharge are discussed.—*WPA*

Artificial Ground Water Production by Biofiltration in Fine Sandy Soils. J. K. BAARS. J. Sci. Food Agr. (London), **8**:610 ('57). Purif. of pold. water by filtration through sandy soil for recharge of ground water is now in operation in Netherlands. Author discusses destruction of polg. substances by soil bacteria and soil conditions which will give best purif. Intermittent system of infiltration, which is used at Leyden water works, is described. Results of anals. of water before and after filtration are given in table. Rate of absorption of bacteria from water on sand grains, and effect of org. and oxygen content of water on bacteria are discussed. Table is given showing variation of nitrogen content of soil receiving faecal poln. Presence of antibiotics and bacteriophage in soil was studied. Methods for removing oxygen from water to be delivered to deep layers are described.—*WPA*

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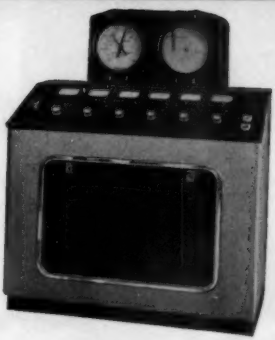

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Service Lines

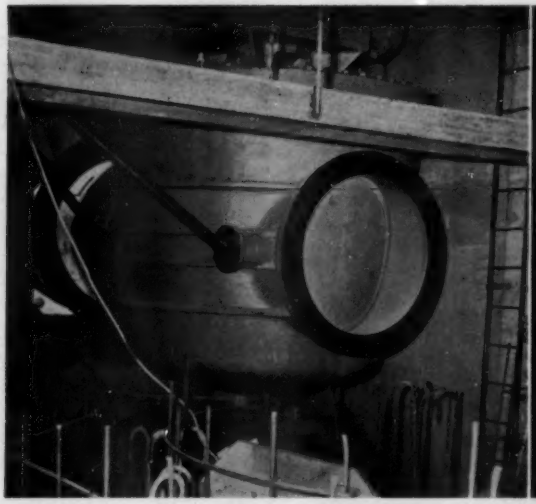
Industrial pH equipment is the subject of an 8-page brochure, Bulletin 5400. The illustrated material gives detailed specifications and descriptions of various types of industrial pH instruments, electrodes, and accessories. A copy may be obtained by writing Beckman Instruments, Inc., Process Instruments Div., 2500 Fullerton Rd., Fullerton, Calif.

Rubber expansion joints and flexible pipe are the subjects of a 6-page, two-color bulletin, Catalog No. 575, issued by General Rubber Corp., Summit & Atwood Sts., Tenafly, N.J.

Pressure regulators are described in a new 28-page bulletin, which discusses applications of the self-operating and the pilot-type models. Tables and graphs permit rapid comparison of various characteristics for selection of the proper type. The bulletin, No. 401, may be obtained by writing Kieley & Mueller, Inc., 64 Genung St., Middletown, N.Y.

Softening equipment, both manually operated and automatic, is the subject of a 12-page publication in which drawings and charts are combined with text to describe the principles and methods of water softening. This bulletin, No. 5782, is available from General Filter Co., 923—2nd St., Ames, Iowa.

Flow metering with the Dall flow tube is described in a 20-page bulletin, which gives comprehensive engineering information on the device. Illustrated with photographs, sketches, charts, and graphs, the bulletin may be obtained by requesting Technical Bulletin 115-L3C from Builders-Providence, Inc., 345 Harris Ave., Providence 1, R.I.



This SMS-Rotovalve at Iron Mountain shows clearly the drop-tight shut-off position. In operation, the conical plug first lifts, then turns, finally reseats, giving you precise aperture control.

3 MORE SMS-ROTOVALVES ORDERED FOR PUMP DISCHARGE SERVICE AT IRON MOUNTAIN

As part of the expansion program for increasing the supply of water to southern California through the Colorado River aqueduct, three more SMS-Rotovalves have been ordered by the Metropolitan Water District of Southern California. These three 48″ x 64¼″ tapered Rotovalves, duplicates of six already installed at Iron Mountain Pumping Station, will be used for pump discharge service. Their inherent characteristics of a large reduction of flow area during the early part of the closing stroke make them ideally suited to control surges in the event of emergency shut-off.

SMS-Rotovalves give the least possible pressure loss. In the open position, their full line opening offers no more resistance than a straight piece of pipe of the same diameter. Hydraulic unbalance and mechanical design make operation easy, and less powerful operators may be used. Rotovalves' flexibility suits them to any type of operation, any method of control, or any sort of location.

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worth of research available in convenient, usable form at less than the cost of printing, which was largely absorbed by the JOURNAL.

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Experience With Water Works Facilities

Containing vital information on the actual life of mains, valves, meters, services and other facilities in 26 cities, together with 56 pages of summary tables that condense the data for easier interpretation.

Presents the facts of life (and death) of the facilities of water supplies serving almost 10 per cent of all U. S. consumers plus 400,000 Canadians.

576 pages

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(*Continued from page 50 P&R*)

Juvenile delinquency has become a ready excuse for many failings these days, but we were hardly prepared to find its implication as a possible cause of water shortage—and in no less respected a publication than *Engineering News-Record*. Just exactly where ENR stands on the matter we're not certain, but it was in its columns and under the headline, "Where Does Ground Water Come From?," that we found an exposition by Michael H. Salzman, vice-president of the Resources Foundation of America, on the importance of "juvenile water" in preventing the ultimate exhaustion of the earth's supply of water from atmospheric sources. "Fixation of water by weathering," it appears, is what would exhaust the stuff of the hydrologic cycle were it not for the makeup supplied through juvenility. And that the fixation is not strictly characteristic of RFA is indicated by the fact that the term derives from a 1937 McGraw-Hill book entitled *Ground Water*, by C. F. Tolman.

As a matter of fact, geologists do recognize that there is such a thing as "juvenile" or "primary" water and some may even go along with its classification into RFA's terms: magmatic water (given up on crystallization of molten rock); volcanic water (formed by the combination of oxygen and hydrogen in molten lava); and metamorphic water (formed by the separation of water from minerals by dehydration and weathering). What geologists do not usually subscribe to is the creation of such juvenile water in quantities adequate to supply springs flowing more than 65 mgd, as implied in the Salzman article. This could only be called juvenile transcendence, much more characteristic of rocks in the head than rocks in the ground.

(*Continued on page 88 P&R*)

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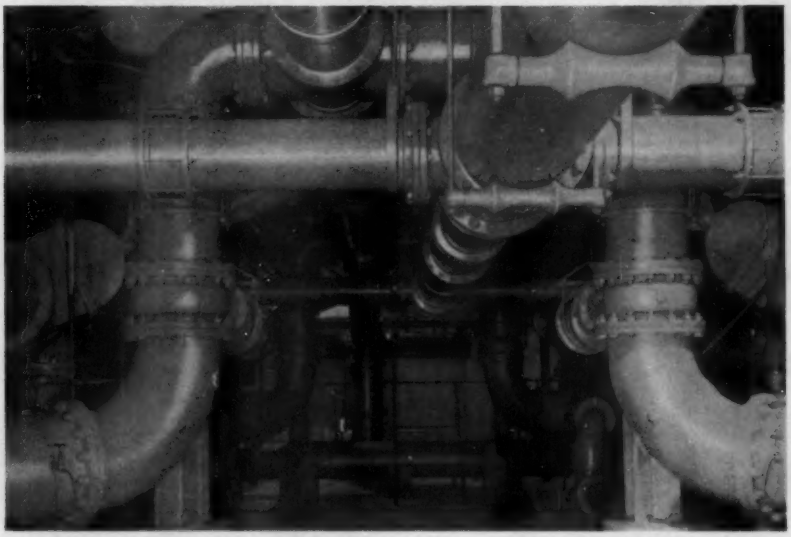

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This new 7 MGD system was built to meet the rapidly expanding industrial and residential needs of Winchester and neighboring areas. For long-term maintenance economy...good looks...and lasting protection, Inertol coatings were specified 100% by Alexander Potter Associates, Consulting Engineers, New York, N. Y., Mr. M. H. Klegerman, Engineer.

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Buy Inertol paints direct from the manufacturer. Shipment within 3 days from our plant, or nearby warehouse stocks. For valuable maintenance painting guide with handy paint selector chart, write today for free folder W587.

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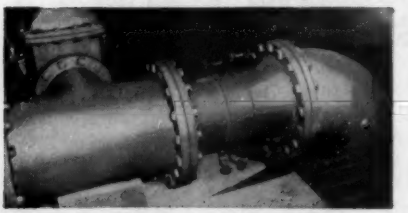

Actual installation of a 16" Flow Tube for REVERSE FLOW. Note fittings (elbow and tee) are bolted directly to flanges of Flow Tube.

Gentile Flow Tubes can be furnished with or without suitable secondary indicating, recording, or totalizing instruments.

GENTILE Flow Tubes are manufactured exclusively by Foster Engineering Company

Write for further information or specific recommendations.

FOSTER ENGINEERING COMPANY

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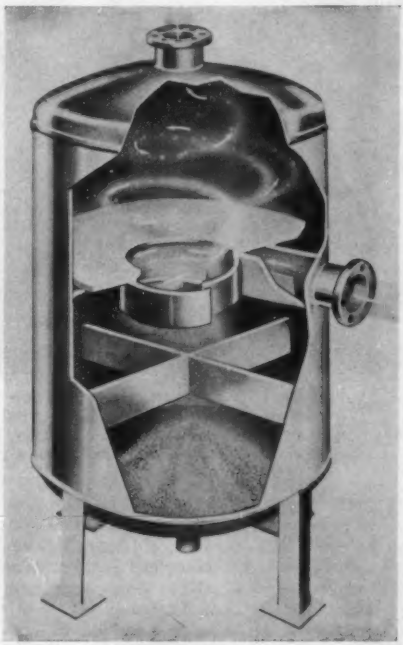
AUTOMATIC VALVES • CONTROL VALVES
SAFETY VALVES • FLOW TUBES

(Continued from page 86 P&R)

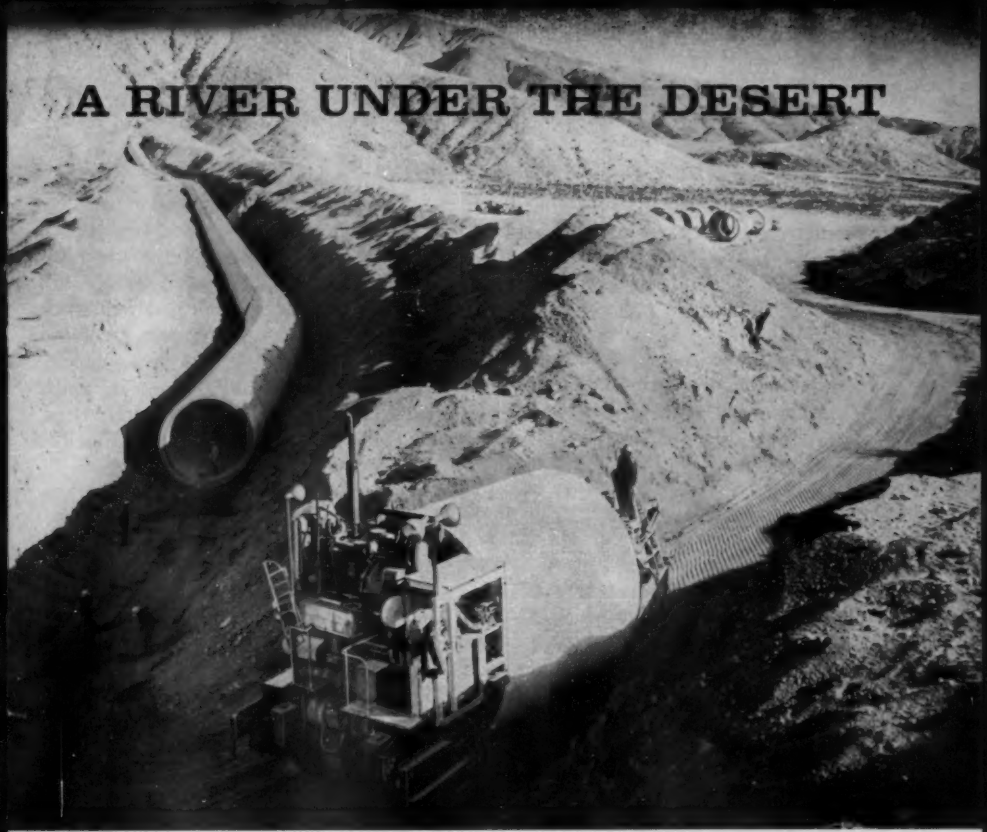
Paul A. Wing has been named vice-president in charge of sales for Smith-Scott Co., Riverside, Calif. He was formerly with US Steel.

Removal of sand and silt from water by the Cole Sand Separator is close to 100 per cent, according to the manufacturer, Walter R. Cole & Co., Oakland, Calif. The unit uses a two-chamber system—one to separate heavier particles by centrifugal-helical action utilizing water at high velocity, and the other to separate residual fine particles by reducing the water velocity below the "fallout" velocity of the particles. Operation of the device is said to produce little pressure drop (2–4 psi), and efficiency is not impaired by



(Continued on page 90 P&R)

A RIVER UNDER THE DESERT



American Pipe and Construction Co. is engaged in the manufacture and installation of 63,000 ft. of reinforced concrete pipe for 47 inverted siphons of the Colorado River Aqueduct. The siphons, widely spaced along a 183-mile segment of the aqueduct, are part of the program of the Metropolitan Water District of Southern California to bring the gigantic water supply line to full planned delivery capacity of over a billion gallons of water per day.

American's solutions to the remote location and magnitude of the project include establishment of two on-the-project manufacturing plants. Hauling of 13 ft. 6 in. diameter 68-ton sections of pipe is accomplished with specially designed 99 ft. trailer-rigs. Approximately 180 miles of access roads are to be constructed. American designed and built the machine shown above to meet special installation problems posed by slopes up to 50% and trenches 125 ft. wide and 50 ft. deep. This unique "Pipemobile" actually carries and installs the pipe.

Today, American Pipe and Construction Co., with over 50 years experience, is more than qualified to handle problems involved in long-distance transmission of large volumes of water.

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(Continued from page 88 P&R)

large fluctuations in rate of flow. Standard models covering a wide range of pressures and capacities are available.

J. A. Frank, vice-president and general manager, National Water Main Cleaning Co., New York, has been named president of the firm, succeeding J. Albert de Camp, who was elected chairman of the board. Mr. Frank will continue as general manager.

Sidney W. Wells, formerly with the Florida Board of Health, has joined the Mackle Co., developers of retirement villages, as assistant utility manager stationed at the Mackle development near Pompano Beach, Fla.

Research assistantships in sanitary chemistry, leading to M.S. and Ph.D. degrees, will be available at the University of Florida beginning in the fall semester. Students selected will work on a USPHS grant project involving basic research in water coagulation. Those interested should get in touch with Dr. A. P. Black, Research Prof. of Chemistry, University of Florida, Gainesville, Fla.

Harry N. Lowe Jr. has been promoted from chief of the Sanitary Engineering Branch to assistant chief of the Civil Engineering Dept., US Army Engineer Research & Development Labs., Fort Belvoir, Va. He succeeds Howard H. Mullins, who was named chief of the newly established Bridge & Marine Group.

(Continued on page 92 P&R)

PHOTOVOLT Line-Operated
pH METER Model 85

A fully stabilized pH Meter at the unprecedented price of $115.00 including set of standard electrodes

Available also with combination electrode at 115.00

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(Continued from page 90 P&R)

A project for revising the USPHS "Drinking Water Standards," last revised in 1946, has been approved by the surgeon general. A group of consultants will be appointed to advise the Public Health Service during the project.

H. Northam Haberer was guest of honor at a testimonial dinner following his recent retirement as superintendent of the Lowville, N.Y., Water Dept., a post he had held since 1942. As mementos of the occasion, celebrating his long and distinguished career of service to the community, Mr. Haberer received a plaque and a gold key fitting all locks on Water Dept. property.

Charles R. Spencer has been appointed executive vice-president of Lynchburg Foundry Co., Lynchburg, Va.

Harry B. Miles, former general manager, Utica (N.Y.) Board of Water Supply, died May 7, 1958, at the age of 78. Born in 1879, he began working for the city of Utica in 1906. Since his retirement as general manager of the Board of Water Supply in 1951, he had been serving the board as secretary. He was a Life Member of AWWA, having joined in 1924.

Fred Quinnell, former city engineer, Roundup, Mont., died May 4, 1958. He was 75. During his lifetime he held several municipal positions in Roundup and also served for a period as city manager of Bozeman, Mont. Recently he had been in private practice as a consulting civil engineer. A Life Member of AWWA (joined in 1922), he was a charter member of the Montana Section and served as its chairman in 1946.

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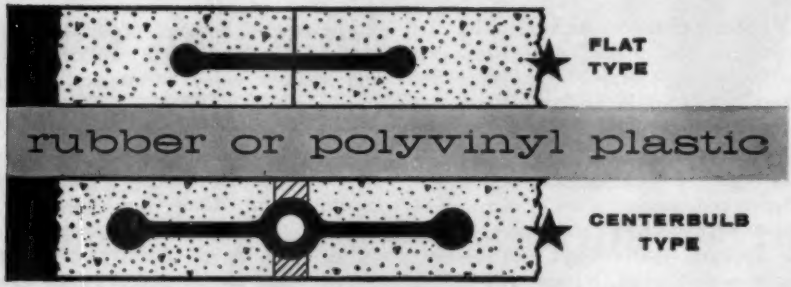

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Vertiseal is an extremely efficient joint sealing compound . . . resistant to petroleum derivatives, most common acids, fats and alkalis. Stable composition, superior cohesive and adhesive qualities, and simple installation with caulking gun or by troweling, make Vertiseal first choice for sealing virtually any type of vertical or horizontal joints.

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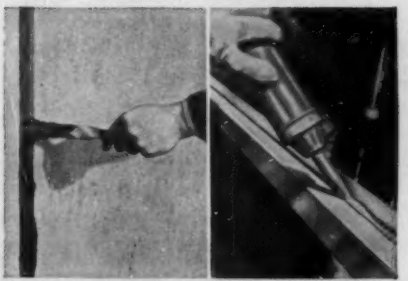

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Section Meetings

Pacific Northwest Section: The 31st annual meeting of the Pacific Northwest Section was held May 15–17, 1958, at the Davenport Hotel in Spokane, Wash. A record 396 men and 110 ladies registered for the sessions.

A highlight of the meeting was an exhibition and demonstration of distribution system equipment and procedures, held at the Spokane Water Dept. Maintenance Yards, with Carl H. Nelson, distribution supervisor, in charge. The 300 persons in attendance voted the exhibit the best ever shown by the Section.

New officers elected for 1958 are: chairman—Herb C. Clare, USPHS, Portland, Ore.; vice-chairman—John Geren, manager, Salem, Ore., Water Dept. and former Section trustee; secretary-treasurer—Fred D. Jones, assistant superintendent, Spokane Water Dept., elected for the fifth time; trustee—Ray Struthers, water superintendent, Pendleton, Ore. E. Jerry Allen is holdover national director, and Aubrey H. Perry is holdover trustee.

The Annual Banquet, presided over by Henry Donnelly, saw 430 members, wives, and visitors enjoy themselves. Roger James acted as master of ceremonies. President Finch talked on "Operation Helpmeet" and also presented the Fuller Award to Claude Vernon Signor, water superintendent, Coos Bay, Ore. The Powell-Lindsay Citation was presented by Mrs. Alexander Lindsay, wife of the former water superintendent whose name the award bears, to James C. Judge, Neptune Meter Co., for his outstanding devotion to the interests of the Section. On all sides praise was given to Mrs. Glen A. Yake and her committee for the finest ladies' program ever put on at a Pacific Northwest meeting. Superintendent Yake of the Spokane Water Dept. received equal praise for the most excellent local arrangements, and Roger James came in for congratulations as chairman of the technical program. [A list of papers and authors will appear in the December JOURNAL.]

FRED D. JONES
Secretary-Treasurer

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FIELD TESTED AND PROVEN LIQUID NON-ACID MATERIAL READY FOR IMMEDIATE USE. REMOVES RUST, SCALE AND INCRUSTATION FROM WELLS AND SURROUNDING GROUND STRATA. ALSO SPEEDS WELL DEVELOPMENT BY DISPERSING SILT. WELL KLEEN IS NON-TOXIC AND NON CORROSIVE AND CAN BE USED WITHOUT DANGER OF BLOWOUT. FOR FURTHER INFORMATION WRITE TO

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QUICKLY LOCATES pavement covered manholes, valve covers, boxes, metal survey or property markers, lost and buried tools, metal beams, in fact any metal below surface or behind brick, plaster or stone siding. Weighs only 7 lbs. Baked wrinkle finish on metal with red lacquered wooden handle—moisture-proofed loop assembly. Send for and try this time tested and proven locator. Immediate shipment.

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*Planned Rehabilitation Program helps city

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account for 94% of water used

through annual "roundup" of defective meters

A near impossible record — but this Midwestern city did it! The community (name on request) began metering when it started its water system back in 1882. One of the nation's first cities to be fully metered, it initiated a planned meter rehabilitation program at the outset. Result: low water waste, high water revenue — as much as 94% of *all* the water used is "accounted for."

Badger's Planned Rehabilitation Program has helped communities all over the country keep their water systems on this same profitable basis. They're installing new, accurate Badger meters where it is economically feasible... new essential parts where only minor repairs are needed.

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If not, it's time your community held its own water meter roundup — to open the way to new revenue . . . end water waste from worn-out meters and parts . . . even help meet rising water department costs. Send for free booklet, "Take 5," outlining the 5 steps to increased revenue through Badger's Planned Rehabilitation Program.

And be sure to ask your Badger representative about our liberal water meter trade-in policy.

Badger Water Meters

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Research makes the big difference in meters Badger builds...

New features for water meters are constantly being developed and tested in Badger's engineering and research departments. Here a chemist inspects plastic specimens tested for dimensional stability. To his right, a test of registers operating under water determines corrosion resistance . . . and an electrolytic analyzer is making a quantitative analysis. From these tests and others will come still greater efficiency and proven durability for future water meters—first from Badger.

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NEW MEMBERS

Alamogordo, City of, Rolla Buck, City Mgr., City Hall, Alamogordo, N.M. (Munic. Sv. Sub. Apr. '58) *MRPD*

Anderson, Floyd E., Asst. Mgr., Orchard Dale County Water Dist., 13819 E. Telegraph Rd., Whittier, Calif. (Apr. '58) *M*

Bagley Public Utilities Com., Thomas B. Gabby, Supt., Bagley, Minn. (Munic. Sv. Sub. Apr. '58) *M*

Banta, Joseph D.; *see* Clyde (Ohio)

Bartholomew, Stephen Lovejoy, Sales Repr., Lock Joint Pipe Co., Box 269, East Orange, N.J. (Apr. '58) *RD*

Bauer, John W., Jr., Sales Mgr., Femco, Inc., Box 32, Irwin, Pa. (Apr. '58) *D*

Benkert, Fred George, Water Plant Operator, Bethpage Water Dist., Adams Ave., Bethpage, N.Y. Apr. '58) *MRPD*

Bingaman, George Chrisman, Div. Repr., Wallace & Tiernan, Inc.,. 4630. Montgomery Ave., Bethesda, Md. (Apr. '58) *RP*

Bonk, Steven, Chem. Engr., Water Works Dept., Corp. of City of Ottawa, Lemieux Island Purification Plant, Ottawa, Ont. (Apr. '58)

Bonnell, Fred, Water Comr., Box 603, Alamogordo, N.M. (Apr. '58)

Bowers, Frank C., Lawyer, 125 Parkway Rd., Bronxville, N.Y. (Apr. '58) *M*

Brereton, Robert M., Cons. Engr., John A. Carollo Cons. Engrs., 3308 N. 3rd St., Phoenix, Ariz. (Apr. '58) *MRPD*

Brisbane County Water Dist., Arthur E. Kennedy, Chairman, 30 Visitacion Ave., Brisbane, Calif. (Munic. Sv. Sub. Apr. '58) *MRPD*

Brown, Walter F., Chief Chemist, Island Filtration Plant, Centre Island, Toronto, Ont. (Apr. '58) *MP*

Buck, Rolla; *see* Alamogordo (N.M.)

Cahoe, Benhardt, Supt., Water Works, Watseka, Ill. (Apr. '58) *MP*

Callender, W. S., Sales Mgr., Seattle Concrete Pipe Co., 7401—8th Ave., S., Seattle 8, Wash. (Jul. '53)

Camel, Blaise G., Member of the Board, E. Jefferson Water Works, 303 Lake Ave., Metairie, La. (Apr. '58)

Campbell, George; *see* Hanford (Calif.) Water Dept.

Campbell, Ronald J., 112 Boylan Lane, Blue Point, N.Y. (Apr. '54)

Canby, City of, Light & Water Dept., A. L. Dunn, Supt. of Public Works, N.E. 2nd & Holly St., Canby, Ore. (Munic. Sv. Sub. Apr. '58) *MRPD*

Cappio, John T., Safety Engr., Water Dept., 1202 City Hall Annex, Philadelphia 7, Pa. (Apr. '58) *M*

Cashman, Charles D., Engr., Clyde E. Williams & Assocs., Inc., 312 W. Colfax, South Bend, Ind. (Apr. '56)

Castelberry, Marvin E., Asst. Gen. Mgr., Utilities Dept., 301 E. Central St., Springfield, Mo. (Apr. '58) *MRPD*

Cavagnaro, Walter John, Sr. Utilities Engr., State Public Utilities Com., State Bldg., San Francisco, Calif. (Apr. '58) *M*

Charles, Robert D., Sr., Water Board Member, Dept. of Water & Sewers, Box 757, Hialeah, Fla. (Apr. '58) *MRPD*

Chlopan, William E.; *see* Troy (Mich.)

Clark, Harry D., Chief Engr., Kankakee Water Co., 1100 Cobb Blvd., Kankakee, Ill. (Apr. '58) *P*

Clark, Robert L., Contractor, Clark Well Drilling Co., 2024 E. Charter Way, Stockton 6, Calif. (Apr. '58) *R*

Clarksville, Town of, Mrs. Ruth J. Sizemore, Clerk, Clarksville, Va. (Corp. M. Apr. '58) *MRPD*

Claunch, Richard S., Exec. Secy., Fair Oaks Irrigation Dist., Box 383, Fair Oaks, Calif. (Apr. '58) *MPD*

Clyde, Village of, Joseph D. Banta, Village Mgr., 606 S. Church St., Clyde, Ohio (Munic. Sv. Sub. Apr. '58) *PD*

Cole, Ernest Julian, City Engr., City Hall, Saskatoon, Sask. (Apr. '58) *D*

Cook, Donald F., Mgr., Glen Cove Plant, New York Water Service Corp., 60 Glen St., Glen Cove, N.Y. (Apr. '58)

Cool, Ralph E., San. Engr., San. Eng. Div., State Board of Health, Raleigh, N.C. (Apr. '58) *MRPD*

Corbin, John P., Water Board Member, Dept. of Water & Sewers, Box 757, Hialeah, Fla. (Apr. '58) *MRPD*

Crum, William P., Mgr., San Dimas Charter Oak Domestic Water Co., San Dimas, Calif. (Apr. '58) *M*

Daniels, J. Graham, Dist. Sales Mgr., Chicago Bridge & Iron Co., 550 W. 17th S. St., Salt Lake City, Utah (Apr. '58)

Day, Lawrence C., Asst. Mgr., Water Dept., Springfield, Mo. (Apr. '58) *MRPD*

Delaware State Board of Health, Floyd I. Hudson, Exec. Secy., Dover, Del. (Corp. M. Apr. '58) *MRPD*

DePagter, Henry, Western Sales Mgr., Badger Meter Mfg. Co., 19400 S. Susana Rd., Compton, Calif. (Apr. '58)

Dunn, A. L.; *see* Canby (Ore.) Light & Water Dept.

Eaton, James B., Sr. Water Serviceman, Los Angeles County Eng. Water Works Div., 419 W. Ave J., Lancaster, Calif. (Apr. '58) *MRPD*

Engle, Willard R.; *see* LeVale (Md.) San. Com.

Ensign, Lew Charles, Supt., Lake Div., Dept. of Public Property, Decatur, Ill. (Apr. '58) *R*

Epplett, Harold H., 1825 N.E. Halsey St., Portland 12, Ore. (Apr. '58)

Erb, D. K., Project Engr., Hunting Tech. & Exploration Services, 1450 O'Connor Dr., Toronto, Ont. (Apr. '58) *R*

Fague, F. F., Asst. Supt., Const. & Maintenance Div., Dept. of Public Utilities, City Hall, Portland, Ore. (Apr. '58)

Fairview County Water Dist., Marlon Lee Pickens, Gen. Mgr., 1971 Placentia Ave., Costa Mesa, Calif. (Corp. M. Apr. '58) *MR*

Fargo, Roman C., Box 1429, Havre, Mont. (Apr. '58)

Finch, Austin E., Water Serviceman, Los Angeles County Water Works Dist. No. 4, 5053 West Ave. L-10, Lancaster, Calif. (Apr. '58) *MRD*

Foley, Marvin E., Lab. Technician, Hefner Water Treatment Plant, Water Dept., Munic. Bldg., Oklahoma City, Okla. (Apr. '58) *P*

Ford, Robert G., Asst. Supt., Water Dept., 304 City Hall, Dallas, Tex. (Apr. '58) *M*

Fry, Earl Stanley, Supt., Water Dept., Naperville, Ill. (Apr. '58) *M*

Gabby, Thomas B.; *see* Bagley (Minn.) Public Utilities Com.

Gaudy, Anthony Francis, Jr., Graduate Student, Dept. of Civ. & San. Eng., Univ. of Illinois, Urbana, Ill. (Apr. '58) *RP*

Geer, Hunter L.; *see* Independent Water Co.

Gelinas, Joseph Onias Gilles, Technician, Public Works Dept., 700 Craig St., E., Montreal, Que. (Apr. '58) *MD*

Goff, Morris E., Plant Operator, Water Works, Bentonville, Ark. (Apr. '58) *P*

Goodrum, Earl E., Field Supt., Water Distr. Div., Dept. of Water & Power, 13514 Erwin St., Van Nuys, Calif. (Apr. '58) *D*

Granold, Charles E., Water Serviceman, Water Works Div., Los Angeles County Engrs., 449 E. Olive, Gardena, Calif. (Apr. '58) *MP*

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Green, Arthur A., Professional Engr., Albert Pipe Supply Co., Inc., 101 Varick Ave., Brooklyn 37, N.Y. (Apr. '58) *PD*

Greenwood, Frank C., Asst. Engr., Metropolitan Water Dist., 703 Tribune Bldg., Salt Lake City, Utah (Apr. '58) *PD*

Grumbling, Jay Sandles, Assoc. Editor, Scranton Publishing Co., 155 E. 44th St., New York 17, N.Y. (Apr. '58) *MRPD*

Hall, Joseph L., Sales Engr., Peerless Pump Div., Food Machinery Chem. Corp., 2005 Northwestern, Indianapolis, Ind. (Apr. '58) *D*

Hanford, City of, Water Dept., George Campbell, Supt., 131 W. 5th St., Hanford, Calif. (Munic. Sv. Sub. Apr. '58) *MRD*

Harbert, Bill L., Vice-Pres., Harbert Const. Corp., Box 1369, Birmingham, Ala. (Apr. '58)

Harriman, Frank B., Asst. Secy., San Luis Rey Heights Mutual Water Co., Star Rte., Bonsall, Calif. (Apr. '58)

Hart, Ray L., Pres., Hart, Reynolds & Assocs., Inc., 154-B Almeria Ave., Coral Gables, Fla. (Apr. '58) *MRP*

Hartman, Ralph L., Supt., Water Works, 154 Millwood St., Caro, Mich. (Apr. '58)

Harvey, J. R., Dist. Engr., State Dept. of Health, 916 Diamond, Meadville, Pa. (Apr. '58)

Hickman, James, Utility Officer, Olathe, Kan. (Apr. '58) *MRPD*

Howell, Billie E., Water Serviceman, Water Works & Utilities Div., Los Angeles County Engrs., 449 E. Olive, Gardena, Calif. (Apr. '58) *RPD*

Hudson, Floyd L.; *see* Delaware State Board of Health

Hughes, Charles Lawrence, Div. Supt., Alameda Div., San Francisco Water Dept., Sunol, Calif. (Apr. '58) *MR*

Independent Water Co., Hunter L. Geer, Supt., 233 Yucca Dr. N.W., Albuquerque, N.M. (Corp. M. Apr. '58) *MD*

Jarnagin, William M., Asst. Sales Mgr., Chemstone Corp., Cleveland, Ohio (Apr. '58) *P*

Jennings, Edward John, Water Works Operations Engr., Los Angeles County Dept. of County Engrs., Rm. 830, 108 W. 2nd St., Los Angeles 12, Calif. (Apr. '58) *MR*

Joens, Arnold C.; *see* Tracy (Calif.)

Jordan, Lester, Water & Sewer Supt., 300 N. Park Ave., Herrin, Ill. (Apr. '58) *MPD*

Judson, Franklin W.; *see* Monroe County (N.Y.) Water Authority

Jurrius, John Peter, Plant Engr., Celco Plant, Celanese Corp. of America, Box 1000, Narrows, Va. (Apr. '58)

Karnath, Vernon C., Operator, Country Club Highlands Sewer & Water Co., Box 304, Elmhurst, Ill. (Apr. '58) *PD*

Kemp, Floyd, Water Board Member, Dept. of Water & Sewers, Box 757, Hialeah, Fla. (Apr. '58) *MD*

Kennedy, Arthur E.; *see* Brisbane County (Calif.) Water Dist.

King, Loyd H., Director, Florida Utilities Div., General Water Works Corp., 1052 Kentucky Ave., Winter Park, Fla. (Jan. '58)

Kirkconnell, Robert, Staff Engr., Nalco, 6216 W. 66th Pl., Chicago 38, Ill. (Apr. '58) *P*

Knuck, Francis X., Water Board Member, Dept. of Water & Sewers, Box 757, Hialeah, Fla. (Apr. '58) *MRPD*

Kronewitter, Ronald A., Supt., Utilities Lab., Michawaka, Ind. (Apr. '58) *P*

Lamb, James C., III, 836 Thomas Ave., Bound Brook, N.J. (Apr. '58)

LaVale San. Com., Willard R. Engle, Secy., Box 182, LaVale, Md. (Munic. Sv. Sub. Apr. '58) *MP*

Layton, Clyde, Supervisor of Water Works, Box 566, Enterprise, Ala. (Apr. '58) *D*

Lee, Il Sun, Water Supply Engr., Water Supply Sec., Bureau of Public Works, Ministry of Home Affairs, Seoul, Korea (Apr. '58) *RD*

LeGrand, Harry Elwood, Cons. Ground Water Geologist, Box 10602, Raleigh, N.C. (Apr. '58) *R*

Lewellen, L. B., Jr., Supervisor of Public Works, Hill City, Kan. (Apr. '58) *MPD*

L'Heureux, Howard B., Cons. Engr., Howard L'Heureux & Assocs., 803 Murray St., Alexandria, La. (Apr. '58) *RPD*

Liebert, Cloyd M., Sr. Water Serviceman, Los Angeles County Water Works, 419 W. Ave. J, Lancaster, Calif. (Apr. '58) *MPD*

Lineberger, James Edward, San. Sales Engr., Dorr-Oliver, Inc., 900 Peachtree St., N.E., Atlanta, Ga. (Apr. '58) *P*

London, Woodrow Parker, Chief Engr., Thermal Div., H. G. Acres & Co. Ltd., Dorchester Rd., Niagara Falls, Ont. (Apr. '58) *RPD*

Lundy, Dale Thomas, Civ. Engr., Alvord, Burdick & Howson, Suite 1401, 20 N. Wacker Dr., Chicago 6, Ill. (Apr. '58) *RP*

Luster, Charles K., City Engr., Mesa, Ariz. (Apr. '58) *MRPD*

MacGowan, Lee F., Asst. Supt., Water Works, Box 149, Watsonville, Calif. (Apr. '58) *RPD*

Magariello, Toney J., Sales Repr., Water Works & Industrial Supply Co., Box 585, Huntington, W.Va. (Apr. '58) *D*

Manning, James D., Sterling Const. Co., Inc., 17138 Oak Dr., Detroit 21, Mich. (Apr. '58)

Marum, Andrew B., Civ. Engr., Marum & Marum, Box 731, Tucson, Ariz. (Apr. '58) *RPD*

McDaniel, Emmett E.; *see* Stillwater (Okla.)

McDonie, Ralph W., Sales Repr., Water Works & Industrial Supply Co., Box 585, Huntington, W.Va. (Apr. '58) *D*

McGrath, John Michael, Sales Mgr., US Electrical Motors, Inc., Los Angeles 54, Calif. (Apr. '58) *R*

McGrenera, Richard A., Salesman, Acid Products Co., Inc., 4010 S. Wells St., Chicago 9, Ill. (Apr. '58) *P*

McIntosh, Benjamin K., Chief Operator, Dept. of National Defence, Camp Wainwright, Wainwright, Alta. (Jan. '58)

Miller, H. D.; *see* Springfield (Mo.) Utilities

Mitchen, Roy, Power Plant Foreman, Crossett Lumber Co., Crossett, Ark. (Apr. '58) *RP*

Monroe County Water Authority, Franklin W. Judson, Chairman, 16 State St., Rochester 14, N.Y. (Corp. M. Apr. '58) *MRPD*

Moser, Lee Joseph, Sales Engr., Byron Jackson Pumps, Inc., 2300 E. Vernon Ave., Los Angeles, Calif. (Apr. '58) *RD*

Moster, Steve J., Water & Sewer Supt., Box 215, Muenster, Tex. (Apr. '58)

Murphey, Edward Ray, Water Comr., Newton, Miss. (Apr. '58) *MRPD*

Nagle, John Marion, Director, Dept. of Utilities, City Hall, Houston, Tex. (Apr. '58) *M*

Perry, George C., Water Works Sales Mgr., Crane Co., Box 1410, Salt Lake City, Utah (Apr. '58) *D*

Petree, George W., Owner, Fluidpower Co., 53 W. Jackson Blvd., Chicago 4, Ill. (Apr. '58) *MR*

Pfarr, Charles N., Partner, Allied Eng. Co., Box 352, Topeka, Kan. (Apr. '58)

Pickens, Marion Lee; *see* Fairview County (Calif.) Water Dist.

Pond, Marshall C., Civ. Engr., Pond Eng. Co., 322 E. Rowland Ave., Covina, Calif. (Apr. '58) *RPD*

Popplewell, J. Murphy, Supt. of Public Works, Mesquite, Tex. (Apr. '58)

Port Arthur, Public Utilities Com. of the City of, E. A. Vigars, Mgr., Public Utilities Bldg., Port Arthur, Ont. (Corp. M. Apr. '58) *MD*

Post, Versal James, Water Serviceman, Los Angeles County Water Works, 449 E. Olive, Gardena, Calif. (Apr. '58) *RPD*

Preciado, Herman Quinn, Water Serviceman, Los Angeles Water Works, 449 Olive St., Gardena, Calif. (Apr. '58) *M*

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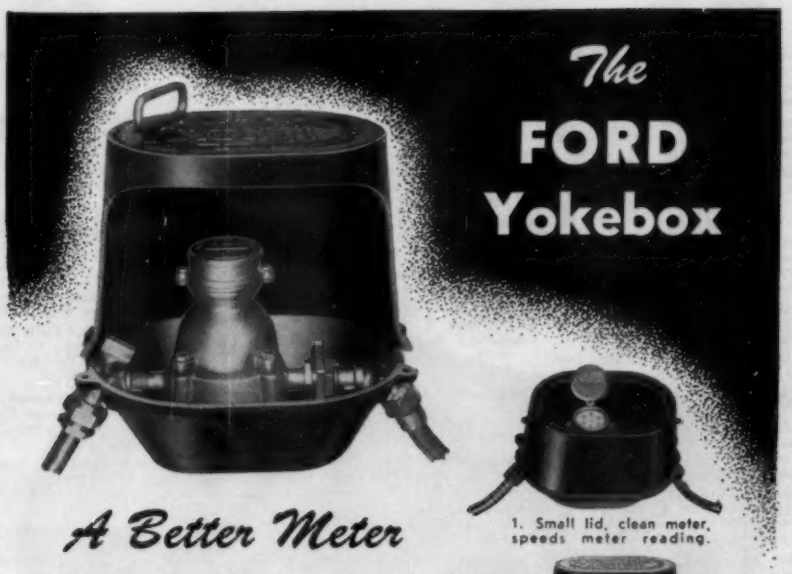

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Proctor, Ruby, (Mrs.), Asst. in Public Relations, Gary-Hobart Water Corp., 650 Madison St., Gary, Ind. (Apr. '58)

Purvis, Melvin H., Supt., Oakway Water Dist., 1421 Coburg Rd., Eugene, Ore. (Apr. '58) *MPD*

Rabold, Richard C., Dist. Engr., Blair Gap Water Supply Co., 815 —9th Ave., Altoona, Pa. (Apr. '58)

Rao, T. B. Krishna, Research Asst., Iowa Inst. of Hydraulic Research, Iowa City, Iowa (Jr. M. Apr. '58) *RPD*

Rash, C. B., Chief Chemist, Mine 1, Minerva Oil Co., Cave-in-Rock, Ill. (Apr. '58) *PD*

Ray, Arliss D., Instructor, Dept. of Civ. Eng., Oregon State College, Corvallis, Ore. (Apr. '58) *RPD*

Redman, Donald Ernest, Sales Repr., Neptune Meters Ltd., 1430 Lakeshore Rd., Toronto 14, Ont. (Apr. '58) *MPD*

Reynolds, Clarence L., Civ. Engr., Hart, Reynolds & Assocs., Inc., 154-B Almeria, Coral Gables, Fla. (Apr. '58) *MRP*

Rice, James K., Vice-Pres., Cyrus Wm. Rice & Co., 17 Noble Ave., Pittsburgh 5, Pa. (Apr. '58) *P*

Rice, Leroy N., Jr., Supt., Sewer Dept., Harlingen, Tex. (Apr. '58) *P*

Roelke, Robert, Chem. Salesman, General Chem. Div., Allied Chemical, 411 N. 7th St., St. Louis, Mo. (Apr. '58) *MP*

Rommel, Morris William, Pres., Benton Plumbing Inc., 506 W. Cross St., Benton, Ark. (Apr. '58) *PD*

Rostron, James T., Asst. Div. Engr., Water Works & Utilities Div., Dept. of Los Angeles County Engrs., Rm. 830, 108 W. 2nd St., Los Angeles 12, Calif. (Apr. '58) *M*

Ryan, J. M., Mgr., Water Works Dept., Harry Cooper Supply Co., Box 1747 SSS, Springfield, Mo. (Apr. '58) *MRP*

Schaumann, Carl John, Asst. Chief Water Serviceman, Los Angeles County Water Works, 419 W. Ave. J, Lancaster, Calif. (Apr. '58) *MD*

Schnobrick, Clarence H., Sales Mgr., Perry-Austen Mfg. Co., 250 Parkinson Ave., Staten Island, N.Y. (Apr. '58) *D*

Schultz, Jack William, Contracting Engr., Chicago Bridge & Iron Co., 550 W. 17th S. St., Salt Lake City, Utah (Apr. '58) *D*

Self, Alvin, Water Supt., Calvin, Okla. (Apr. '58) *M*

Sharp, Hiram J., Supervisor, Plant Maintenance, Water Dept., City Hall, Dallas, Tex. (Apr. '58) *MP*

Sharp, Wayne S., 501 River Rd., Louisville 2, Ky. (Apr. '58) *P*

Sizemore, Ruth J. (Mrs.); *see* Clarksville (Va.)

Slade, Carlton J., Water Board Member, Dept. of Water & Sewers, Box 757, Hialeah, Fla. (Apr. '58) *MRPD*

Smetana, William J., Sales Engr., Johns-Manville Sales Corp., 611 S. Catalina St., Los Angeles 5, Calif. (Apr. '58) *D*

Smith, Alfred, Chief Operator, Water Plant, 201 S. Broadway, Salem, Ill. (Apr. '58) *MRPD*

Smith, William Wagner, Assoc. Civ. Engr., Dept. of Water Supply, 735 Randolph St., Detroit 26, Mich. (Apr. '58) *PD*

Sonefeld, Robert L., Supt., Water Works, Freeland, Mich. (Apr. '58) *MR*

Springfield Utilities, H. D. Miller, Gen. Mgr., 301 E. Central St., Springfield, Mo. (Corp. M. Apr. '58) *MRPD*

Steeg, Wally, Repr., Magnolia Supply Co., Box 13071, New Orleans, La. (Apr. '58) *M*

Stenman, Alex, Supt., Public Works, Exeter, Calif. (Apr. '58) *MRP*

Sterlin, Aaron, Field Engr., Infilco, Inc., 325 W. 25th Pl., Chicago, Ill. (Apr. '58) *P*

Stillwater, City of, Emmett E. McDaniel, Mgr., Water & Elec. Dept., Munic. Bldg., Stillwater, Okla. (Corp. M. Apr. '58) *MD*

Stott, Charles, Sales Engr., Morrison Supply Co., Box 70, Fort Worth, Tex. (Apr. '58) *RD*

Stromblad, Lloyd, Water Serviceman, Los Angeles County Water Works, 449 E. Olive, Gardena, Calif. (Apr. '58) *MRPD*

Swift, Joseph V., San. Engr., Dorr-Oliver, Inc., 4117 Broadway, Kansas City 11, Mo. (Apr. '58)

Tamburrino, Frank Joseph, Water Serviceman, Water Works & Utilities Div., Los Angeles County Engrs., 108 W. 2nd St., Los Angeles, Calif. (Apr. '58) *PD*

Taylor, Robert B., Salesman, Water Pipe & Supply Co., Inc., Voorheesville, N.Y. (Apr. '58) *D*

Taylor, Tom Milton, Sr. Design Engr., Black & Veatch, 1500 Meadow Lake Parkway, Kansas City, Mo. (Apr. '58) *P*

Thomas, Clarence W., Mgr., Consolidated Water Co., Phoenix, Ariz. (Apr. '58) *MD*

Tiernan, Joseph W., Los Angeles County Water Works, 449 E. Olive, Gardena, Calif. (Apr. '58) *MRPD*

Todd, Michael C., Mech. Engr., Div. of Filtration Design, Bureau of Eng., 320 N. Clark St., Chicago 10, Ill. (Apr. '58) *P*

Tracy, City of, Arnold C. Joens, Director of Public Works, 1035 Central, Tracy, Calif. (Munic. Sv. Sub. Apr. '58) *MD*

Troy, City of, William E. Chlopan, Director of Public Works, 50 W. Wattles Rd., Troy, Mich. (Corp. M. Apr. '58) *D*

Vermillion, Jim E., Sales Engr., Minneapolis-Honeywell Co., Dallas, Tex. (Apr. '58) *PD*

Vigars, E. A.; *see* Public Utilities Com. of the City of Port Arthur (Ont.)

Vinick, Albert G., Field Force Engr., Inland Steel Co., East Chicago, Ind. (Apr. '58) *M*

Von Muhlenfels, Ludvig, Managing Director, The Sentab Pressure Pipe Consortium, Barlastgatan Malmo SV, Sweden (Apr. '58) *D*

Waite, Harlow E., Field Engr., Pitometer Assocs., Inc., 50 Church St., New York, N.Y. (Apr. '58) *MRD*

Walker, Edward Raymond, Supervisor of Water & Sewage Pumping, Water Dept., Dallas, Tex. (Apr. '58) *MRD*

Walker, John Thomas, Student, Civ. Eng., State Univ. of Iowa, Iowa City, Iowa (Jr. M. Apr. '58) *MD*

Webster, Raymond Albert, San. Engr., Levitt & Sons, Inc., Levittown, N.J. (Apr. '58) *MRPD*

Weisskopf, A. I., Asst. Secy., General Waterworks Corp., 1506 Walnut St., Philadelphia 2, Pa. (Apr. '58)

West, George P., Indus. Sales, Water Works, Crane Co., Box 1410, Salt Lake City, Utah (Apr. '58) *M*

White, George C., Div. Mgr., Wallace & Tiernan, 2180 Palou Ave., San Francisco 24, Calif. (Apr. '58) *P*

Wildman, Quentin J., Munic. Water Supply Engr., Baker-Harza, Box 328, Amman, Jordan (Apr. '58) *RD*

Williams, Authala, Chemist, Water Treatment Plant, Denton, Tex. (Apr. '58) *P*

Wingfield, F. E., Salesman, Infilco, Inc., Box 2998, Little Rock, Ark. (Apr. '58)

Wonnacott, Vaughn B., Asst. Engr., Metropolitan Water Dist., 703 Tribune Bldg., Salt Lake City, Utah (Apr. '58) *MRPD*

Wright, William L., Director, Sarasota County Health Dept., Court House, Sarasota, Fla. (Apr. '58) *MRPD*

Yocum, Woody F., Distr. Supt., Southern California Water Co., 315 S. Bradford Ave., Placentia, Calif. (Apr. '58) *MD*

Yost, Walter P., Sales Repr., Water Works & Industrial Supply Co., Box 585, Huntington, W.Va. (Apr. '58) *D*

Zyniewicz, John J., Jr., San. Engr., Water Safety Control Sec., Dept. of Water, 3300 E. Cheltenham Pl., Chicago, Ill. (Jr. M. Apr. '58) *P*

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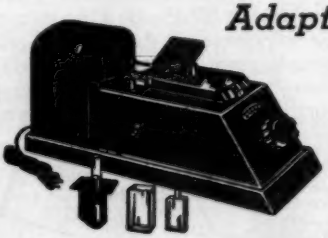

Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

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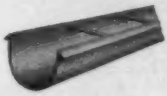

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FIG. 56
- Inside Screw
- Non-Rising Stem
- Parallel Seats
- Bell Ends

FIG. 571X
- Inside Screw
- Non-Rising Stem
- Parallel Seats
- Mechanical Joint Ends

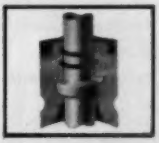
FIG. 561
- Inside Screw
- Non-Rising Stem
- Parallel Ends
- Flanged Ends

FIG. 566
- Outside-Screw-and-Yoke
- Rising Stem
- Parallel Ends
- Flanged Ends

Construction features . . .

Conventional stuffing box

with adjustable gland has ample space for packing that conforms to Federal specification HH-P-106c. The bottom face of the stuffing box flange is faced smooth to form bearing surface for stem thrust collar.



O-Ring seals

once installed no adjustment of any kind is required. The top O-Ring is the dirt seal and the bottom O-Ring is the pressure seal.

Operating nut

is Higher Strength Cast Iron. The base flange, with arrow indicating direction to oper., is shaped to permit access from ground surface to adjust gland nuts with an extension socket wrench.

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R. D. Wood Co.

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Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Simplex Valve & Meter Co.

Waterproofing:
Barrett Div.
Inertol Co., Inc.
Koppers Co., Inc.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
W. A. Taylor & Co.
Wallace & Tiernan Inc.

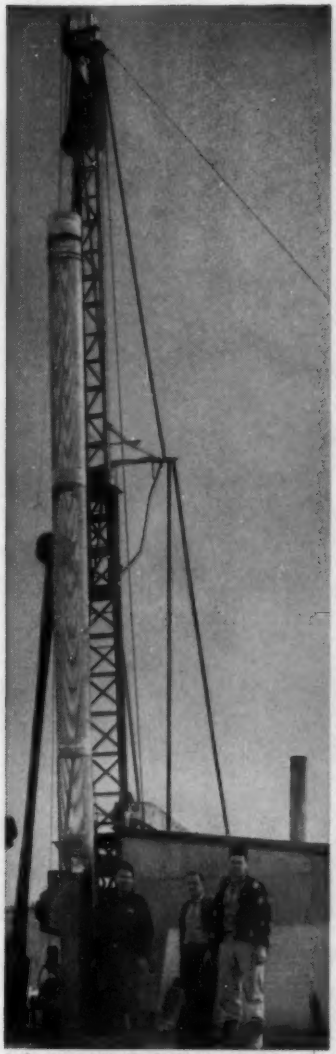
Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hammond Iron Works
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite: see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1957 AWWA Directory.



Johnson Well Screen of Everdur being lowered into the new 4-mgd well at Plymouth, Mich.

Big screen of EVERDUR serves new 4,000,000-gallon well in Plymouth, Mich.

In developing a new source of water to meet growing community needs, Plymouth, Mich., more than doubled the capacity of its water system with a single well capable of providing 4,032,000 gallons per day.

The new well is 110 feet deep, has an 18-inch casing, and a Johnson Everdur Well Screen 16¼" in diameter by 32', 1½" long. Edward E. Johnson, Inc., St. Paul, Minn., fabricates tough, corrosion-resistant well screens from specially shaped Everdur wire and rod by a unique automatic welding method. Johnson welded Everdur screens have proved their durability by years of service in large-capacity wells.

• **Everdur* resists corrosion.** Sewage-treatment and waterworks equipment of Everdur has been in service without replacement for 20 years and longer.

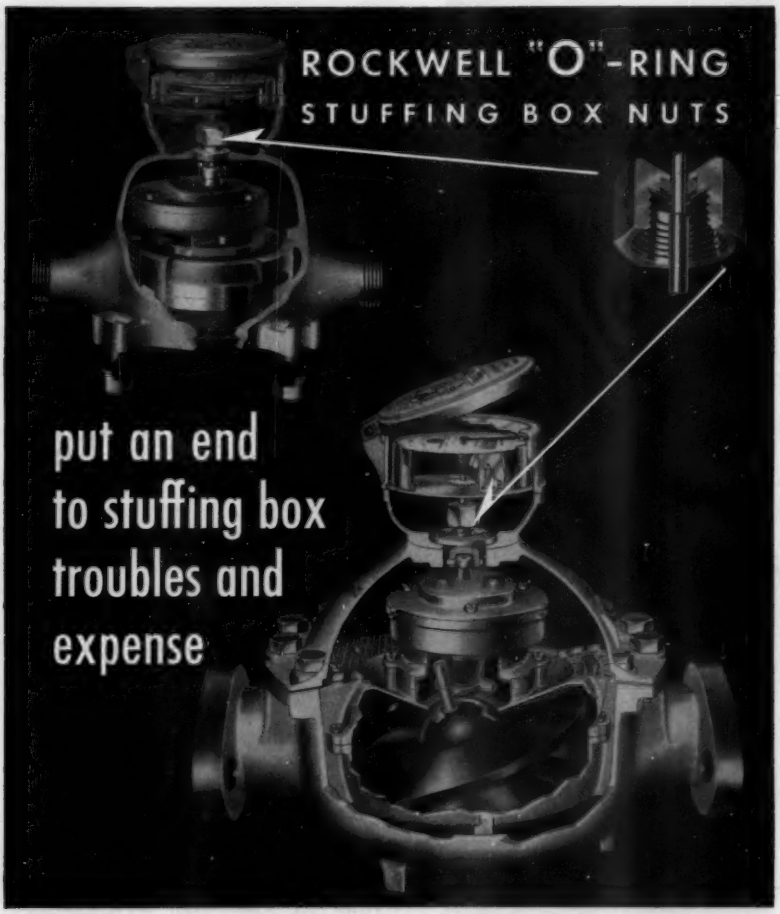
• **Everdur is tough.** Everdur also possesses high mechanical strength and resistance to wear and abrasion—so that engineers can design light-weight, wrought-metal equipment.

• **Everdur is readily fabricated.** Alloys are available for hot or cold working, welding, free machining, forging, and casting – and can be obtained in plates, sheets, rods, bars, wire, tubes, electrical conduit, and casting ingots.

• **Write for Publication E-11,** "Everdur Copper-Silicon Alloys for Sewage Treatment and Waterworks Equipment"—or for technical help in selecting the correct material for your job. Address: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

*Reg. U. S. Pat. Off. 87122

EVERDUR Anaconda's Family of Copper-Silicon Alloys
MADE BY THE AMERICAN BRASS COMPANY
STRONG • WORKABLE • WELDABLE • CORROSION-RESISTANT



EXCLUSIVE* CONSTRUCTION ELIMINATES LEAKS, BINDS

Rockwell "O"-Ring stuffing box nuts provide a *leak tight seal* on the register drive spindle. This seal is accomplished with *very slight compression*, so friction becomes negligible and meter performance is actually improved. This construction is *foolproof*, since the "O"-Ring nut can be force tightened with a wrench without applying any additional compression.

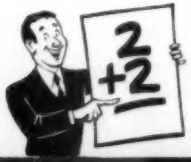
Seven years of field experience have proved the success of this *exclusive* Rockwell development—now furnished as standard construction on Rockwell meters at no additional cost. And Rockwell "O"-Ring stuffing box nuts are available as interchangeable replacement parts for earlier model Rockwell meters. Ask your Rockwell representative to demonstrate. Rockwell Manufacturing Co., Pittsburgh 8, Pa.

*Patented

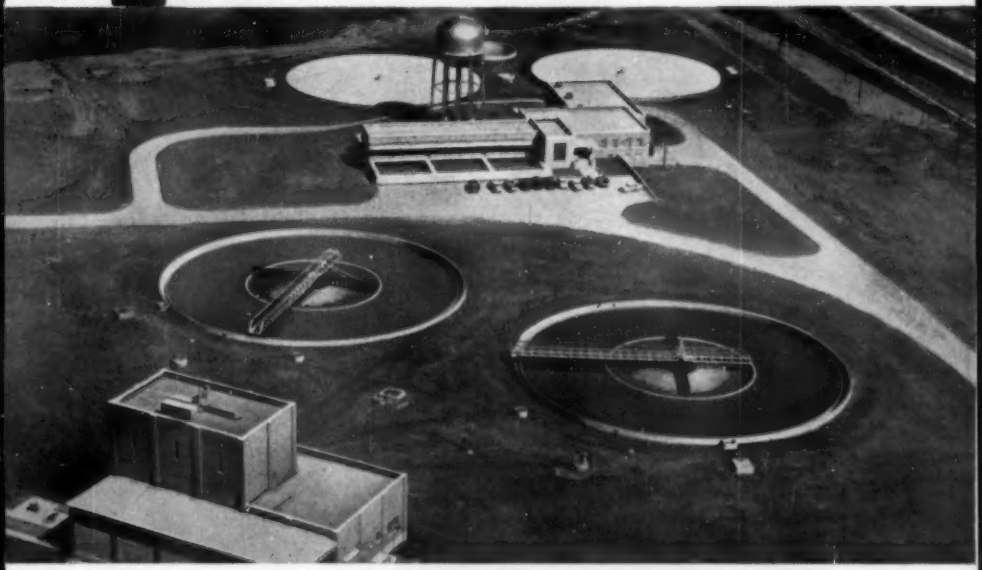
WATER METERS
another fine product by
ROCKWELL

The solution to this problem is always the same . . . but

Water Treatment Problems are different



No two water treatment problems are exactly alike. The right solution to each can be arrived at only after a careful study of local conditions. Variables such as raw water consumption, rate of flow and results required automatically rule out the cure-all approach. The installation shown below is a good example of how equipment should be selected to suit the job . . . and not vice versa.



North Texas Municipal Water District

World's largest Clariflocculators

Each 170-ft. in diameter and having a 14-ft. swd, the Dorr-Oliver Clariflocculator units shown above are two of the world's largest. Each unit provides for a 66 minute flocculation period and a settling period of 4.53 hours at a plant output rate of 20 MGD. This installation at Wylie, Texas, for the North Texas Municipal Water District, is another example of the widespread preference for Dorr-Oliver equipment. For information, Write to Dorr-Oliver Inc., Stamford, Connecticut.

Consulting Engineer: Forrest & Cotton, Dallas, Texas.
Design Engineer: Ormond A. Stone, Dallas, Texas.
General Contractor: C. H. Leavell & Co., El Paso, Texas.

Every day over 8½ billion gallons of water are treated by Dorr-Oliver equipment

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WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT
STAMFORD • CONNECTICUT • U. S. A.

*Clariflocculator—T.M. Reg. U.S. Pat. Off.

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Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking